

SCAFFOLDING PRESERVICE TEACHERS' NOTICING OF ELEMENTARY  
STUDENTS' SCIENTIFIC THINKING

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Susan R. Hawkins

*Dedication*

*For my dad who always told me I could do anything.*

*For my husband who believed in me more than I believed in myself.*

*For my mom and sister who loved me unconditionally.*

*For my daughter who makes it all worthwhile.*

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First of all I'd like to thank my family especially my husband and daughter for supporting me through these past five years. Your love, encouragement, pep talks and shoulder rubs kept me going when I didn't feel like it was possible.

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My dad was right when he said, "When you finally figure out what it is that you have to do to graduate; you do!"

Susan R Hawkins

Scaffolding Preservice Teachers' Noticing of Elementary Students' Scientific Thinking

To effectively meet students' needs, educational reform in science calls for adaptive instruction based on students' thinking. To gain an understanding of what students know, a teacher needs to attend to, probe, and analyze student thinking to provide information to base curricular decisions, upon. These three components make up the skill of noticing. Learning to notice is not easy for any teacher, but is especially difficult for preservice teachers, who lack the experience these skills require. Additionally they lack the professional knowledge needed to inform responses.

The purpose of this study was to discover how a combination of scaffolds: video-based reflection on practice, a professional learning community, and a content specific moderator as a guide can be embedded into a methods course to support preservice teachers' learning to professionally notice elementary students' scientific thinking in order to provide a responsive curriculum. The study was designed on the premise that the skill of professional noticing is critical for preservice teachers to acquire the knowledge and ability to develop their personal PCK and topic specific professional knowledge.

It was situated in a methods course as this is the structure provided within teacher education programs to tie theory to practice. This qualitative case study, studied one section of an elementary science methods course during teaching of their science unit.

In general participants' skills progressed from noticing the class as a whole to attending to specific students' thinking and from a focus on evaluation to interpretation. By the end they were connecting teaching strategies to student thinking. How

participants' responded to what they had noticed progressed as well, moving from frontloading information to creating additional constructivist based learning experiences when encountering student confusion demonstrating growth in their professional knowledge as well as their noticing skills.

They attributed certain aspects of their growth to different parts the intervention, for instance learning to probe thinking to video, learning to construct learning experiences to the content specific moderator, and learning to decide next steps to the professional learning community.

This study points to the efficacy of employing these scaffolds, found useful in other contexts, within science education.

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## CHAPTER 1

### INTRODUCTION

Educational reform in science calls for an adaptive curriculum that is designed specifically to respond to students' needs. Teachers need to view teaching and learning as a dynamic, evolving process to design and present lessons that are responsive to student needs (Mason & Spence, 1999). Paying attention to student thinking, a practice called "professional noticing," provides teachers with the information necessary to provide learning situations tailored to students' particular contexts (NRC, 2015; Schweingruber, & Quinn, 2012).

Professional noticing refers to how teachers attend to, interpret, and respond to students' thinking to make instructional decisions (Jacobs, Lamb, & Philipp, 2010; Jacobs, Lamb, Phillip, & Schappelle, 2011). This is a critical skill in developing professional knowledge for teaching. All three components (attending, interpreting, and responding) inform the personal pedagogical content knowledge which is needed to provide the responsive curricula called for in the reform documents (Gess-Newsome, 2015; NRC, 2015; Schweingruber, & Quinn, 2012). Pedagogical content knowledge (PCK), a term coined by Shulman (1986), describes a knowledge base consisting of an amalgamation of subject matter and pedagogy that distinguishes teachers from content experts. It is both topic and grade level specific. As a result of discussions during the 2015 summit on re-examining PCK in science education, Gess-Newsome (2015) created a model of teacher professional knowledge that "identifies the overarching role of professional knowledge and situates PCK within that model, including all the

complexities of teaching and learning” (p 30), providing an updated understanding of a teacher’s knowledge base.

The complex, tacit practice of noticing student thinking involves the skill of recognizing critical incidents (van Zee, Hammer, Bell, Roy & Peter, 2005). After noticing critical points, teachers need “to engage students in discourse that fosters their progress” (van Zee et al., 2005, p.1010), during which the pedagogical skill of questioning comes into play (Roth, 1996; van Zee et al., 2005). Teachers can then analyze students’ current understandings and use the information gleaned to guide their instructional decisions (Atkin, Black, & Coffey, 2001; van Zee et al., 2005).

Researchers have found that teachers can improve their noticing skills by redirecting their attention to focus on student thinking, analysis of lesson outcomes, and decisions based on evidence (Jacobs, Lamb, & Philipp, 2010; Sherin & van Es, 2005). By evaluating students’ ideas, educators can make informed choices about what learning experiences their students will benefit from most.

Learning to provide a responsive curriculum can be challenging for any teacher, but is especially difficult for preservice teachers, who have limited experience attending to student thinking, as well as limited PCK with which to make informed instructional decisions (Abell, 2007; Davis & Smithey, 2009). Additionally, preservice teachers spend much of their time focusing on issues related to classroom management (e.g., student behaviors, materials management, etc.) and are insecure about veering too far away from pre-existing lesson plans. These concerns prevent them from attending to student thinking (Appleton & Kindt, 2002). Even when preservice teachers are able to identify critical junctures in learning and use questioning appropriately to probe for student thinking, they



often are at a loss as to what to do with the information (Sherin & van Es, 2005). This lack of practical knowledge results in missing important “in the moment” teaching opportunities to improve student understanding of science content. It also prevents them from making sound decisions concerning how their curriculum should progress. Given the challenges of learning to professionally notice, it is suggested that this skill be initiated early on in teacher development (Davis, Petish, & Smithey, 2006; Stockero, 2014; Talanquer, Tomanek, & Norvodvorsky, 2013). Accordingly, the present study investigates the effectiveness of an intervention that scaffolds preservice teachers’ acquisition of professional noticing as a critical component of their PCK for teaching science.

### **Conceptual Framework**

Reflection, the mainstay of improving educational practice, is the key for developing the skill of professional noticing. Through reflection teachers can analyze their practices, examine and confront their beliefs, and move away from the role of disseminators of knowledge and toward one of facilitators of student learning (Calderhead & Gates, 1993). Abell and Bryan (1997) assert that a reflective orientation “help(s) preservice teachers construct viable science teaching and learning theories and classroom practices” (p.164). Many times, however, preservice teachers are unprepared for the reflective tasks asked of them. For example, assessing the effectiveness of a progression of lessons in a science unit may require knowledge preservice teachers do not possess (Calderhead, 1989). Therefore, developing a reflective disposition may require extensive scaffolding, which may take many forms.

The literature details many approaches to assist in the process of developing the practice of reflection, among which video feedback and professional learning communities (PLCs) are prime examples, both of which have been proven to be useful in developing reflective practice and the skill of professional noticing. Although the majority of studies have focused on contexts other than preservice science education, (e.g. inservice professional development and mathematics education), I assert that the practices of reflection and professional noticing are relevant to the preparation of elementary teachers within the context of a science methods course to develop their knowledge of how students learn, a critical component of PCK for teaching science (Abell, 2007; Davis & Smithey, 2009).

This study draws on the literature of PLCs as a context for developing collaborative reflection on teaching practice. PLCs were developed as an offshoot of Wenger's (1998) concept of communities of practice (CoP), which affirm the social, collaborative nature of learning. Both types of communities have members who share goals and interests. Additionally, in both, members work together to solve problems of practice and support each other in achieving and maintaining positive changes. PLCs differ from CoP in that membership is not voluntary. PLCs do however share with CoP the ability to effect lasting change (Dana, Campbell, & Lunetta, 1997).

Another approach utilized in guiding collaborative reflection is the use of instructional coaches (Stover, Kissel, Haag, & Shoniker, 2011). An instructional coach meets the diverse needs of teachers by offering support in learning to reflect on their own practices. Coaches also give technical feedback, and guidance in analysis and adaption of instruction to teachers' specific contexts (Joyce & Showers, 1982). Therefore, including

a content specific instructional coach as a member of a PLC may support preservice teachers' acquisition of the skills necessary for developing their ability to professionally notice student thinking about particular topics. I assert that offering this level of support in a teacher preparation program will initiate preservice teachers' personal PCK development (Gess-Newsome, 2015).

Video has been used widely in many contexts to enhance reflective practice. Since video allows the complex and often tacit aspects of teaching to be viewed iteratively, removed from the distractions of the classroom and the responsibilities of teaching, it is an excellent tool to foster awareness of student thinking and thus professional noticing. Additionally, reflecting on videos of preservice teachers' own practices overcomes the limitations of vicarious reflection on the practices of experienced teachers (Mulholland & Wallace, 2001). Viewing videos of their own and their peers' classroom performance is more beneficial for preservice teachers because it depicts teaching within their proximal zone of development, thus enhancing their self-efficacy for teaching science (Mulholland & Wallace, 2001; Ross, 1992; Santagata & Guarino, 2011). Furthermore, using video to unpack their own practices presents opportunities for preservice teachers to evaluate and challenge their ways of interacting with students and constructing learning experiences (Abell & Bryan, 1997). Therefore, reflecting on videos of their own teaching may serve to reframe preservice teachers' focus away from themselves as disseminators of knowledge and direct it instead to their students' learning needs.

However, research has shown that video by itself is not a panacea and needs to be viewed with a clear purpose in mind and with the aid of focusing tools to direct attention

to particular areas or topics. Without maintaining focus, preservice teachers may miss important learning situations or misinterpret teacher/student interactions (Friel & Carboni, 2000; Santagata & Guarino, 2011; Sherin & van Es, 2005). Friel and Carboni (2000) reason that teachers need assistance with translating theory into practice, for which they need support in understanding how to enact these ideas into their practice. A variety of focusing tools are discussed in the literature, such as online or other computer based programs, elaboration activities, lesson analysis frameworks, and coupling viewing with live observations or face to face guidance and modeling (Friel & Carboni, 2000; Santagata & Guarino, 2011; Sherin & van Es, 2005).

This research employed the use of a content-specific moderator (myself) to provide preservice teachers with face to face guidance on how to use videos of their own and their peers' teaching to develop the three components of professional noticing: attending to, interpreting, and deciding how to responding instructionally. This experience was conducted within the context of small teaching group PLCs of four to five preservice teachers working together to create, teach, and reflect on a five-lesson science unit. Originally I planned a whole-class PLC component to extend the participants' learning beyond their specific context to consider larger implications for their PCK development. However, after completing two sessions with the PLCs, I found that the whole group component was not effective in helping preservice teachers build their noticing skills, so I replaced it with a component focused on guiding the preservice teachers to notice student understanding and apply what they learned within their individual PLCs.

As the PLC's content-specific moderator, I guided preservice teachers in building an understanding of the relationship between professional noticing and their PCK development. My approach to moderating was modeled on that of an instructional coach (Sailors & Shanklin, 2010; Zwart, Wubbels, Bolhuis, & Bergen, 2008). This model addresses the need for guidance in learning to reflect on video as well as to work cooperatively with a professional community (Hull, 2009). The coaching relationship allowed me to act as both a model and a focusing agent for how to effectively reflect on student thinking while viewing videos of their own practices. My role as the content specific instructional coach, henceforth referred to as a content specific moderator, also allowed me to support the functioning of the PLCs. I viewed my role in the PLCs as a guide to help preservice teachers develop awareness of how they talked with elementary students and used the information they accessed to guide their instructional decision making and set up and facilitate learning situations that encourage their students to construct their own learning (Mason & Spence, 1999). In my role as content specific moderator, I endeavored to cultivate a classroom environment that encouraged all participants to develop this level of awareness.

### **Background and Purpose of Study**

The present study is an extension of an earlier study in which I examined how the combination of video-based reflection, a preservice professional learning community, and a content specific moderator could help a group of preservice elementary teachers learn to notice students' scientific thinking in order to make effective curricular decisions.

In that study I worked with a group of five preservice teachers enrolled in a science methods class and associated early field experience in which they planned and

taught a five-lesson science unit in a local elementary school. Our PLC met weekly outside of their regular class time to review video of each lesson taught and discuss modifications to the next week's lesson based on evidence of students' understanding of scientific concepts. As the content specific moderator, my role was to guide the group in learning to notice, as well as to advise them in other areas of their professional knowledge development such as subject matter, curriculum, and teaching strategies. Together we reviewed the recording of their science lesson each week, stopping at points where we noticed places where the lead teacher either did a good job of attending to student thinking or failed to take the opportunity to probe student thinking. We then discussed possible alternatives to the interaction and what could be done to remedy it as well as ramifications for the unit's progression. I was able to model and scaffold this process for them, taking the lead at first and then relinquishing it as they became comfortable with the process.

The intervention resulted in positive gains for the preservice teachers. By the end of their science unit they were consistently probing the elementary students' thinking to inform their curricular decisions. The participants were also keeping lesson objectives and standards in mind as they planned, set up and orchestrated learning activities, and they came to understand and appreciate the benefits of a learning cycle approach (which places exploration before formal concept introduction) to designing instruction that helps students to construct understandings of science concepts based on experiences with related phenomena.

There were of course areas in which some participants still needed improvement, such as a preoccupation with classroom management at the expense of attention to

student thinking. Their fixation on managing the classroom also affected material selection, limiting the effectiveness of their lessons. Additionally the PLC I instituted in this initial study, although showing promise, did not adequately address the problem of preparing preservice teachers to learn to notice student thinking to provide a responsive curriculum in science due to the time intensive nature of the meetings for both the preservice teachers and the content specific moderator.

In designing my dissertation intervention I drew from a new model of teacher professional knowledge resulting from discussions held at the 2015 PCK summit. This new model situates PCK within five teacher professional bases: knowledge of assessment, pedagogy, content, students, and curriculum. Gess-Newsome describes these bases as generalized professional knowledge. This generalized knowledge both informs and is informed by topic specific professional knowledge, such as knowledge of instructional strategies, content representations, student understandings, science practices and habits of mind, which are then amplified or filtered by teachers' beliefs and contexts and which both affect and are affected by classroom practice. Classroom practice refers to personal PCK, representing a combination of knowledge and skill applied within a particular classroom context. My third research question investigates how the intervention scaffolds assisted the progress of participants' personal PCK, a concept Gess-Newsome defines as "the knowledge of, reasoning behind, and planning for teaching a particular topic in a particular way for a particular purpose, to particular students for enhanced student outcomes" (2015, p. 36). As personal PCK both affects and is affected by topic specific professional knowledge via the amplification or filtering of teachers' beliefs, these two areas are also discussed with respect to my findings.

Considering the positive findings in my earlier study, I wanted to explore a way to extend the gains made by one small group to an entire methods course. Therefore, I sought to understand how the use of the three tools (video-based reflection on one's own practice, preservice PLC, and guidance from a content specific moderator) could be extended to an entire methods course consisting of four teaching teams of four or five preservice teachers each. More specifically, I hoped to identify what scaffolds from the previous intervention would be useful and which might need modification, as well as what additional supports might be necessary in order to support the preservice teachers in constructing knowledge of professional noticing focused on student thinking. This study therefore aimed to explore the impact of a combination of training tools in the development of PCK for elementary preservice science teachers. The training tools are professional community, video self-reflection and coaching by a subject matter expert. Specifically, I investigated how preservice teachers' knowledge of students' scientific thinking, pedagogy for teaching science (e.g., specific instructional strategies), and ideas for designing a responsive science curriculum would develop as a result of experiencing the model of community-based reflective practice implemented in this study.

The findings of this study serve to inform the field of science teacher education about how reflecting on videos of preservice teachers' own teaching, within the context of a content specific moderated PLC, can scaffold their "personal PCK and topic specific professional knowledge for science teaching (Gess-Newsome, 2015).

### **Structure of the Dissertation**

In the second chapter I present a review of the literature relevant to the three scaffolds for professional noticing via reflective practice that constitute the intervention



in this study. For each component I first define the approach and its underlying educational reasoning before detailing research on the results of utilizing it in different contexts. In my coverage of reflective practice, I begin my review of the literature with a focus on video based reflection before narrowing my discussion to the effect of video-based reflection on attention to student thinking and professional noticing. I then review literature on professional communities, looking first at research on CoP and then on PLCs. Third, I provide a brief review of the literature on professional coaching to define my role in the intervention as the content specific moderator, before ending with a discussion of gaps in the literature and the significance of this study to the field of science education.

Chapter three details my research methodology, beginning with a description of the research approach selected for this study, qualitative case study. I then relate my choice of a case study approach to my research questions. Next, I describe the context and participants, and my role as both researcher and participant in the study. Finally, I provide a comprehensive overview of my methods for data collection and analysis, concluding with a description of how I address issues of potential researcher bias and ensuring trustworthiness in my reported findings.

Chapter four discusses my findings, organized by research question. The first question, examining how the participants' noticing progressed, presents information about the levels participants attained both initially and near the end as laid using van Es' framework for noticing (2011). The chapter begins with an overview of what and then how teachers noticed, and finally to what scaffolds participants attributed their changes. The three components are discussed first separately and then in combination. Next I

progress to presenting findings for the second research question addressing how participants modified their instruction based on what they learned about student thinking. This section discusses the themes that emerged related to changes in skill levels before discussing the aspects of the intervention to which they attributed their progression, first individually and then in combination. Finally, relevant to the third question, the five themes that emerged from the data are discussed in detail: 1) how to design instruction, 2) the purposes of questioning, 3) strategies for delivering instruction, 4) progression of ideas, and 5) instruction guided by student thinking. Each theme is introduced before giving specific examples from the data, and relevant components of topic specific professional knowledge as outlined in Gess-Newsome's 2015 model. The last part of the discussion of this question covers the progression of participants' beliefs and how these beliefs acted as either amplifiers or filters for growth.

Chapter five first presents a brief summary of the first three chapters and then a more detailed summary of the findings, before discussing them in relation to the literature. Topics covered in this section are noticing, support provided by the intervention scaffolds, personal PCK and topic specific professional knowledge, and finally the power of beliefs. I end the chapter with conclusions, implications and recommendations for further research.

## CHAPTER 2

### LITERATURE REVIEW

Previous research suggests the promise of video and professional communities as well as instructional coaching in promoting reflective practice. Reflecting in turn scaffolds teachers' professional noticing of students' thinking. Noticing then facilitates building teachers' pedagogical content knowledge. Exemplary teachers draw upon the unique body of knowledge referred to as Pedagogical Content Knowledge (PCK) to guide their instructional decision making. It is this form of professional knowledge that sets teachers apart from content experts (Shulman, 1986; 1987). Because science teacher educators are responsible for preparing preservice teachers to be prepared for the complex task of teaching they need to guide preservice teachers in initiating what Davis and Smithey (2009) term "PCK readiness" (p. 765). It is this knowledge that will guide them in adapting their instruction to meet their students' needs (Avraamidou & Zembal-Saul, 2010; Davis & Smithey, 2009; Hollon, Roth, & Anderson; 1991). Building their personal PCK will prepare them to establish an effective classroom practice and develop their topic-specific professional knowledge (Gess-Newsome, 2015). By structuring experiences for preservice teachers to reflect on their teaching of "a particular topic in a particular way for a particular purpose to particular students" (Gess-Newsome, 2015, p. 36), teacher educators can scaffold them in creating a foundation for learning to teach. With this foundation, preservice teachers can build a framework to draw on once they enter their own classrooms. My dissertation study combines the elements of video based reflection, professional communities, and instructional coaching to determine their effects on scaffolding elementary preservice teachers' noticing of students' scientific thinking.

In this chapter I review the literature on what is known about employing these three scaffolds, as well as how they may contribute to developing preservice teachers' beginning PCK for teaching science. I am particularly interested in how preservice teachers use the information they gain from probing student thinking to assess and modify their planned instructional trajectory. I am also interested in preservice teachers' ability to attend to students' scientific thinking during the act of teaching, as well as how these teachers learn to assess such thinking in order to guide their instructional decisions.

This review is divided into five major sections. The first two sections relate to reflective practice. The first section refers to reflective practice in general. It contains three subsections, beginning with reflection in teacher education, narrowing to science teacher education, and then closing with a discussion of professional noticing within reflective practice. Although still under the umbrella of reflective practice, the second section, *Video as a Tool in Reflective Practice*, is highlighted because it constitutes a major focus of my dissertation study. It is also one of the three elements that I am employing to scaffold preservice teachers' professional noticing. This section contains two subsections: the first focuses on video usage for reflective practice in education, and the second narrows to examine video in science teacher education as a tool for attending to student thinking. The third major section details the literature on professional communities, an umbrella term I use to include both communities of practice (CoP) and professional learning communities (PLCs). This section is broken down into subsections as well, including communities of practice in education, professional learning communities in education, and professional communities in science education. The fourth section reviews the coaching literature, with a focus on connecting this practice to my

study, especially to the role of the content specific moderator. Finally, the fifth section covers gaps in the research and the significance of my study.

### **Reflective Practice**

Reflective practice forms the backbone for professional growth in education. Via metacognition, an integral element of reflective practice, teachers focus on their own teaching as a tool to improve practice. Learning to reflect also plays a substantial role in teaching preservice teachers to think like teachers. Additionally, reflective practice helps teachers to make the tacit components of teaching explicit, so various elements can be examined, discussed, analyzed, and modified if necessary. Reflection is therefore the basis of learning to notice professionally.

### **Reflective Practice in Teacher Education**

Jay and Johnson (2002) asserted that reflective practice is paramount to learning to teach. They described learning to reflect as a process that takes place both individually and collectively. In reflective practice, teachers grapple with questions both individually and with others to solve problems in their practice. The authors described a reflective practitioner as someone who is able to examine a dimension of their teaching from a number of perspectives, as well as communicate their thoughts about it with their peers. Jay and Johnson (2002) focused on three dimensions of reflection used in their weekly seminars: descriptive, comparative, and critical. The researchers guided their preservice teachers to understand the three dimensions through the introduction and modeling of useful strategies. The authors discussed the struggle they faced in finding a balance between providing sufficient scaffolding and reducing reflection to a series of steps. They realized that assigning portfolio requirements and providing seminars was not enough to

teach reflective practice and that continually evolving understandings of reflection had to be considered when planning teacher education programs.

Being metacognitive about an aspect of one's teaching and then sharing those insights with colleagues defines the core of reflective practice. Research, however, suggests quite a bit of variation in perspectives about what else reflective practice encompasses. Calderhead (1989) discussed a number of these variations, ranging from Dewey's purposeful search for an answer, to Schön's "reflection in action," referring to decisions made while teaching. Schön saw reflection as a series of steps in trying to make sense of a situation where the participant frames and then reframes their understanding. Dewey, on the other hand, saw reflective practice as a more holistic process. Other reflective philosophies, such as Habermas's critical view, include contextual and societal influences as contributing factors. Calderhead (1989) detailed the importance of providing "early field experiences...and discussions between the teacher and the student (the preservice teacher) about teaching" (p.45). The author asserted that giving preservice teachers practice in analyzing their own teaching assists them in learning to guide their own professional development. He also proposed that teacher education programs push preservice teachers to consider how they would modify educational environments based on moral or ethical considerations. Hatton and Smith (1995) asserted that many definitions of reflection are either inadequate or inappropriate. They contended that reflective practice is developmental, beginning with a focus on the technical aspects of the lesson, then move to reflecting on action, and finally they develop the skill to be able to reflect while in the act of teaching (Hatton & Smith, 1995). Although there are many

differing approaches to structuring a reflective curriculum, the uniting factor is a focus on cognition.

Differences in reflection also apply to approaches to educating preservice teachers for a reflective teaching orientation. Calderhead (1989) detailed several important considerations in the design of preservice teacher education programs. As discussed in Chapter 1, he contended that many of the activities that preservice teachers are asked to complete are beyond their capabilities and require extensive guidance to ensure success. Calderhead also warned that the culture of the school community may devalue the role of reflection. Additionally, he argued that, conceptions of reflective teaching are not honed enough to provide for the variety and complexity of preservice teachers and contexts. Hatton and Smith (1995) outlined five additional problems associated with facilitating a reflection orientation: 1) reflection is not usually associated with work as a teacher, 2) teachers have persistent preconceptions and misconceptions about teaching, 3) teachers lack of clarity about the knowledge necessary to understand and apply concepts, 4) some learners experience discomfort in examining firmly held beliefs, and 5) the belief systems held at many school sites conflict with a reflective ideology. I believe that professional learning communities (PLCs), especially when paired with a moderator utilizing coaching strategies to focus and guide the group's attention, will provide solutions for many of these preservice education issues.

Reflective practice is not easy to teach or learn; there are many considerations in designing teacher educator programs with a reflective orientation (Calderhead, 1989). In addition to difficulties in ability to carry out reflective tasks, gathering hard evidence to analyze levels of reflection also presents a challenge. However, one study by Hatton and

Smith (1995) in which they analyzed student work for evidence of three types of reflection (descriptive, dialogic, and critical) does just that. After analyzing the data, the authors created a framework, based on Schön's work, for considering different types of reflection: reflection in action; reflection on action; and technical rationality (made up of technical decisions). Scaffolding reflective practice, however, is obscured by the implicit nature of teaching, making issues difficult both to uncover and confront.

I propose scaffolding preservice teachers' reflective practice by instituting a PLC within the context of a methods course in order to encourage both individual and communal reflection and create a viable avenue for building preservice teachers' PCK. This structure would enable teacher educators to tailor learning situations based on their community's needs. They may, however, encounter Jay and Johnson's (2002) tension of finding an appropriate balance between scaffolding reflection and reducing it to a series of steps. The end goal in employing these methods is to enhance preservice teachers' abilities to reflect during instruction so that they can make more effective instructional decisions in the moment as well as longer range determinations about curricular trajectories.

### **Reflective Practice in Science Education**

There is less research on frameworks for reflective practice in science education than other areas. However, Abell, and Bryan (1997) contributed to the literature by detailing the components of their reflection orientation science methods course. Their approach centered on the concept of orientation as portrayed by Magnusson, Krajcik and Borko (1999) stating that it "refers to a teachers' knowledge and beliefs about the purposes of teaching and serves as a conceptual map to guide instructional decisions"



(Abell & Bryan, 1997, p. 153). They described orientation as something that gives preservice teachers opportunities to reflect by themselves as well as collaboratively with others. The authors provided multiple opportunities for preservice teachers to reflect on their own and their peers' teaching. Abell and Bryan's (1997) justification for utilizing this type of pedagogy was based on their belief that learning to teach science calls upon the skills of "clarifying, confronting, and expanding one's ideas, beliefs, and values about science teaching and learning" (p. 164). The authors used activities to help students identify their own ideas and assess how they were acquired to highlight the impact of experiences. The researchers also employed additional activities to help preservice teachers confront their ideas to accommodate ideas more in line with current educational research on science teaching and learning. Furthermore, they incorporated instruction (and asked preservice teachers to design instruction) that took into account research-based pedagogies. The authors' prime goal, a goal they asserted all teacher educators who teach based on a reflective teaching orientation should hold, was to understand and challenge how preservice teachers think. In addition to providing a sound pedagogy for teaching future teachers, this strategy models a way of teaching that preservice teachers should employ in their own classrooms one day. However, there is a need for more research specifically aimed at examining reflective practice in science education.

The amount of research done on reflective practice within science education compared with that done in other subjects, especially mathematics, comprises a gap that needs to be addressed. Its applicability to science seems especially plausible, as science is focused on clarifying, confronting, and expanding ideas, paralleling reflective metacognition of practice (Abell & Bryan, 1997).

## **Professional Noticing**

Professional noticing, a construct introduced in math education, necessitates reflective practice. Although studies define noticing differently, all tie noticing to making sense of complex situations (Santagata, Zannoni, & Stigler, 2007). It is focused on “in the moment” decision-making requiring teachers to analyze and connect situations with what they know about teaching and learning (Lampert, Beasley, Ghouseini, Kazemi, & Franke, 2010). The studies point to teachers’ views of classroom interactions being undergirded by their individual lenses. These lenses are created by the teachers’ unique experiences. Extrapolating this idea leads to the premise that providing teachers with certain experiences can influence their abilities to notice in certain ways (Jacobs, Lamb, & Phillip, 2010).

Jacobs, Lamb and Phillip (2010) asserted that teachers can improve their noticing skills by changing what they notice: for instance, by shifting their focus from their own teaching to targeting students’ thinking or reasoning, moving from describing what occurred to analyzing lesson outcomes, and moving from judgment to reasoning based on evidence. Rosaen, Lundeberg, Cooper, Fritzen, and Terpstra (2008) presented research pointing to changes in focus (i.e., from classroom management to instruction and from themselves to their students’ ideas) as well as in the specificity of what they notice as a result of video-supported reflection.

In the complex landscape of the classroom, teachers must be selective about what they address. Frederiksen (1992) coined the term “call out” to describe the behavior of selecting a portion of interest while participating in video-based reflection which van Es and Sherin (2002) extended to include the ability to select significant occurrences while

teaching. Thus acknowledging that knowledge of context is important when interpreting interactions and in using interpretations to guide pedagogical decisions (van Es & Sherin, 2002). Another important aspect is connecting incidents to overarching teaching principles.

Noticing can be applied to many aspects of teaching. Van Es and Sherin (2006) apply it to attending to student thinking as a basis of instructional decision making to provide a responsive curriculum. The researchers investigated video clubs, a type of community of practice (which I discuss in depth in the section on communities) in which teachers come together to discuss video of each other's teaching. Although all structures of this type of community of practice had positive effects on teachers' growth, the study added that employing a knowledgeable researcher/facilitator to narrow teachers' focus to student thinking and encourage interpretation of occurrences is especially important when working with novice teachers. This study aligns with what I plan to investigate, differing only in studying inservice teachers instead of preservice teachers and in focusing on science education instead of mathematics education. In Instructional Coaching, the penultimate section of this review, I outline the approach that I will employ.

### **Video as a Tool in Reflective Practice**

Video of student/teacher interactions has proven a valuable tool in scaffolding reflective practice. Star and Strickland's (2008) study pointed to the positive effect of video on developing preservice mathematics teachers' observational abilities. Likewise Sherin and van Es (2005) described research with a video support tool called VAST within the context of an inservice middle school mathematics video club. They also reported on these communities' use with both preservice mathematics and science

teachers. Their study uncovered “changes over time in what the teachers noticed and in how they interpreted these events” (p. 475).

Video of practice has been used widely as a tool for encouraging productive discussions about teaching and learning mathematics (Borko, Jacobs, Eiteljorg, & Pittman, 2008; Friel & Carboni, 2000; Santaga & Guarino, 2011; Towers, 1998; Bloomberg, Sherin, Renki, Glogger, & Sidel, 2013). It is from this platform of study that science education researchers should begin to build their own body of research on video usage for supporting reflective practice. Video is powerful because of its ability to realistically portray teaching in a way that can be viewed iteratively. Video can be stopped, replayed, and manipulated in order to focus teachers’ attention on certain aspects of the teaching/learning process. It also allows time for important processing and metacognition. Through examining video in a professional learning community, preservice teachers can discuss possible alternative pedagogical strategies with peers, thus bringing in the benefits of multiple viewpoints (Borko et al., 2008). This iterative quality—especially when situated within a professional community (discussed in next section)—can help make the tacit aspects of teaching explicit. The usefulness of video, however, is not without stipulations.

### **Video Usage for Reflective Practice in Education**

Brophy suggested that video is not useful in and of itself and needs to be viewed with a clear purpose in mind (as cited in Borko et al., 2008). Clips should be viewed with specific goals in mind. Teacher educators can purposefully select video clips to focus teachers on specific aspects of the teaching/learning interaction. They may use episodes to illustrate common problems in teaching and learning or to provide problem-solving

opportunities and give practice in proposing alternate solutions (Friel & Carboni, 2000). One of the main advantages of video is its usefulness in turning teachers' focus to their students, instead of on themselves. This focus improves their ability to uncover how students think (Towers, 1998). Santagata and Guarino (2011) contended that activities presented in correlation with video can help guide preservice teachers in learning to pay attention to significant details of how students think about mathematical (or scientific) ideas and also how instructional moves can assist in pulling out those ideas. The researchers chose video clips for particular purposes and utilized a Lesson Analysis Framework to help focus preservice teachers on certain aspects of the teaching/learning process. The purposes (as set out in the Lesson Analysis Framework) led the researchers to select video based on the content portrayed, visible student thinking, and students' or teachers' backgrounds. Santagata and Guarino tailored the clips they chose to build on the orientations and skills contained in their framework. This type of structured use of video has proved to be especially useful for supporting teachers' improvement of specific components of their teaching. Teacher educators, whose job is to build preservice teachers' PCK, can use focused video viewing to this end.

Friel and Carboni (2000) detailed another benefit of focused video-based reflection on teaching that is especially pertinent to preservice teachers. Due to the inadequacy of the preservice teachers' PCK, they do not have the proficiency to make sense of learning situations in the same way experienced teachers do. When preservice teachers observe in classrooms, they miss a great deal. They may totally miss important learning situations or misinterpret teacher/student interactions (Friel & Carboni, 2000). Friel and Carboni (2000) based their study on the premise that "learning to teach is a

developmental process focused on the dilemmas of teaching” (p.118). They argued that methods courses need to facilitate preservice teachers’ replacing existing ideas with ones more in line with currently accepted best practices. To achieve the accommodation of new ideas, the researchers asserted that practice needs to be melded with research and that university courses should be constructed using the latest research findings. My study addresses this concern.

In observing three cases over the course of a year, Friel and Carboni (2000) found that preservice teachers were more focused on themselves as teachers than on what the students were actually talking about. Although the preservice teachers realized that they needed to pay attention to student thinking and allow students to express their ideas, they did not make the jump to realizing that this information should be used to make instructional decisions. The researchers used video in their mathematics methods course to facilitate preservice teachers’ attention to their students’ developing mathematical thinking. Video assisted this process by allowing the preservice teachers to focus on listening to student ideas. Friel and Carboni also used curriculum designing activities to focus the preservice teachers on students’ sense-making. I believe that the result of this research can be applied to science education because learning to become an effective science teacher is also a developmental process. This process begins with paying attention to student thinking and then using information gleaned to tailor curriculum to respond to students’ needs.

The objective of a responsive curriculum is to improve student learning by modifying curricular trajectory to fit students’ needs. Santagata and Guarino (2011) added elaboration activities to help preservice teachers realize how instructional decisions

affect student learning. The activities, paired with focused video viewing, helped preservice teachers to create a framework for reasoning about teaching in a more integrated way. Data analysis showed that after participation in the activities, 50% of the participants were spontaneously able to offer alternative pedagogical moves. Research studies corroborate the effectiveness of video viewing paired with activities in building preservice teachers' PCK.

Other modifications such as having preservice teachers examine footage of their own teaching can add to video's effectiveness (Putnam & Borko, 2000; Bloomberg et al., 2013). Borko et al. (2008) hosted a situative professional development featuring teachers working together to improve practice while situated within their own classrooms. Putnam and Borko's (2000) description of the situated nature of knowing provided the theoretical framework for this professional development. Situated knowing contextualizes knowledge within a teacher's own classroom to provide a more powerful learning situation. Putnam and Borko's (2000) study sought to compare the effectiveness of using video as a reflective tool within two learning environments, one situated and the other cognitive. Their research uncovered different reflection patterns across the two groups selected from a single methods course. The results of comparing their participants' learning journals showed that the cognitive group, which received more direct guidance initially, yielded more advanced reflections including some description and evaluation but a predominance of integration. This pattern, however, was not maintained over time. In contrast, the situated learning group was slower to reach more advanced levels of reflection but maintained their growth levels over time. The cognitive group's data pointed to the benefits of providing guidance, in the form of prompts, when first

introducing video. The researchers concluded that if expert level reflections are needed in a short time span then a cognitive approach should be employed, but if long-term reflection is the desired goal, a situated approach is more effective. This study corroborates the sustained benefits of situating professional development within teachers' actual practice.

Using the teachers themselves as the subject of reflection also proves to be a beneficial strategy. Participants found watching video of themselves extremely useful. In fact some participants stated the most valuable part of the professional development was watching their own teaching (Borko et al., 2008). Participants also found it useful to watch others teach the same lesson that they themselves had taught. Tower's (1998) study, which featured the use of video of the methods instructor teaching instead of preservice teachers, corroborates the benefits of having the featured teacher present when viewing video footage. The ability to ask questions and discuss the events in more detail made some of the tacit aspects of the teaching event more explicit. Additionally, since Tower's (1998) participating instructor was not holding herself up as the expert with all the answers, the strategy assisted in creating a low-stress environment conducive to learning. Finally, this kind of context allowed preservice teachers to see themselves as integral members of an educational community. These studies corroborate the beneficial aspects of using teachers' own practice as a reflective tool, even at the preservice level.

Borko et al.'s (2008) study adds an additional component by combining the supportive environment of a community of practice with focused video reflection. In their study, they examined video clubs, as did van Es and Sherin (2008), where teachers tape, review, and reflect on their own teaching. Through their research, they discovered that



the conversations taking place facilitated critical examination of teaching and promoted meaningful conversations about teachers' own practice. The findings showed that what teachers discussed changed over time as they participated in the communities. However, this level of open sharing does not take place automatically. To encourage this type of discourse, a safe, comfortable environment must be established. Borko et al. (2008) employed an article called "The New Heroes of Teaching" (Hiebert, Gallimore, & Stigler, 2003) to help reduce anxiety and frame videotaping of teachers' classrooms in a positive light. As a result, many teachers in the program characterized watching the video of themselves and their peers teaching as desirable. In fact, they felt so empowered by the experience that they took the initiative to continue the process on their own. It is this type of sentiment that will perpetuate continued reflective practice.

The benefits of utilizing video for reflection extend beyond the advantages previously discussed and actually surpass those of real time teaching. Borko et al. (2008) maintained that video provides a viable alternative to going out to an actual classroom. The researchers claimed that video accurately portrays the complexity of a classroom environment while allowing teachers to reflect on interactions, without the restrictions or distractions of a real-time situation. Video also allows perceptions that may be missed when observing in a classroom, such as providing an overview of the classroom environment or capturing small group work or one-on-one teacher/student discussions. All the positive aspects of video, however, does not mean that the practice of using video for reflection is without stipulations.

Video alone is not a panacea for building PCK. To be effective, video usage must be used in conjunction with activities in order to build preservice teachers' skills.

Santagata and Guarino (2011) recommended coupling video viewing with live observations to make scenarios more realistic and engender greater confidence in what is being viewed. The researchers asserted that providing guidance and modeling is necessary to focus the preservice teachers on important aspects of teaching. They believed that this guidance is important because it instills an organized approach to reflection that may benefit the preservice teachers throughout their careers. Additionally, the authors proposed that video of their own practice is more effective because it is closer to the preservice teachers' "zone of proximal development" (p. 21), making it easier to connect with than watching video of a teacher with a more advanced skill set.

Video-based reflection provides many benefits both for preservice and inservice teachers. For example, video takes advantage of authentic portrayal of learning situations without the distractions of real time teaching. Additionally, utilizing video of preservice teachers' own practice makes reflection more relevant and thus more useful. Finally, educational research points to the effectiveness of pairing video with other strategies to help focus reflection and connect theory to practice.

### **Video in Science Teacher Education: A tool for Attending to Student Thinking**

Building upon the studies involving mathematics education, science education research is starting to forge its own path. Even though studies involving both inservice and preservice science teachers attending to student thinking employ varying strategies, all enable teachers to assess what students know by focusing on students' thinking. Rosaen et al. (2008), saw the potential for video of teaching in action to "improve their (preservice teachers) ability to support, analyze and assess K-12 student learning through discussion" (p. 358). By studying how video facilitated preservice teachers'

understanding of handling whole class discussions, the researchers could determine its benefit for inclusion in their teacher education program.

Rosaen et al. (2008) studied attending to student thinking during whole class discussions, whereas Martin and Siry (2012) investigated the benefits of providing preservice teachers with case studies in order to promote reflective practice and to scaffold their analyses of classroom interactions following instruction. They described communities of practice called video clubs that consist of inservice teachers and a facilitator. These video clubs met at school sites to watch and analyze clips of each other's teaching. Van Es and Sherin (2008) asserted that video clubs provided a shared experience to frame teachers' discussions of student learning. Martin and Siry (2012) argued that examining case studies in the context of these clubs gave preservice teachers practice in using decision-making skills, as well as scaffolded their attention and possible responses to student thinking by modeling how to approach dilemmas in practice. The researchers maintained that video helped to tie theory to practice (Martin & Siry, 2011). They proposed that video helped to bring unspoken decisions and thought processes out in the open, facilitating reflective practice. Additionally, the real world context allowed preservice teachers to glimpse what Shulman (1992) called "images of the possible" (as cited in Martin & Siry, 2012, p.9).

Roth, Garnier, Chen, Lemmens, Schwille, and Wickler (2011) reported on a project called Science Teachers Learning from Lesson Analysis or STeLLA. STeLLA consisted of a year-long professional development that used video to help scaffold teachers in both content knowledge and pedagogy in addition to guiding them in learning to analyze their teaching. The researchers compared a content-oriented (control) group

with an analysis-oriented group. The researchers identified the benefits of embedding content and pedagogy in a real context, engaging teachers in long-term collaboration, intertwining content and pedagogy, making specific content a focus and organization around theories of teacher learning. The STeLLA program had participants view science through two lenses: student thinking and science as a story line. The STeLLA program emphasized student thinking through the inclusion of five strategies to help teachers learn to uncover, support, and challenge student thinking. These strategies included: eliciting student ideas and predictions, asking probing and challenging questions, having students interpret and reason about observation and data, asking students to use and apply new ideas in a variety of contexts and/or ways, and encouraging students to make connections through summarizing and synthesizing work. Sherin and van Es (2005) were also interested in using video to support attention to student thinking. They employed a video support tool called VAST to focus on student thinking. The program allowed teachers to examine clips of their own and others' classrooms. The various strategies utilized by researchers took advantage of video's ability to bring the tacit to light by supporting teachers in uncovering, disassembling, and analyzing student thinking and their responses to it.

Various research studies focused on attention to student thinking highlighting the iterative nature of video, but detailing different benefits. Martin and Siry (2012) pointed to the benefit of the iterative nature of building progressive understandings of science teaching. Rosaen et al. (2008) focused on how specific details of interactions can be viewed repeatedly in order to glean the importance of certain events in building student understanding. While Roth et al. (2011) used video for iteratively viewing teaching

through a variety of lenses, to provide a reference point to focus discourse and as a useful and reliable source of evidence for claims. The research studies, although focused on different components, all strove to understand how teachers build their PCK for attending to student thinking.

Review of the research supports the assertion that video helps to focus preservice teachers on instruction instead of management issues. This was overwhelmingly the focus of the group relying only on memory in Rosaen et al.'s 2008 study. In the VAST study, teachers improved their abilities to pull out significant events and that focus took precedence over a focus on the sequence of events. Teachers in Sherin and van Es's 2005 study shifted from attending to pedagogy to attending to student thinking and from evaluating to interpreting events. Finally, the results of Rosaen et al.'s (2008) study uncovered that video-based reflection created dissonance to a greater degree, causing preservice teachers to confront their preconceptions and misconceptions, thus helping them to advance their understanding of teaching and learning. Research has consistently shown video as a useful tool to promote attention to student thinking.

Other researchers (Friel & Carboni, 2000; Sherin & van Es, 2005; Rosaen, et al., 2008; Santagata & Guarino, 2011) explored the use of video as a tool for both pedagogical reflection and PCK development. They found that video assisted preservice teachers in reconstructing their orientations and beliefs about how children learn, moving them from a didactically focused pedagogy to a more child-centered one. Also, researchers discovered changes over time in what preservice teachers noticed, what they focused on, and how they interpreted events, thus suggesting that research agendas should include investigations with a lateral dimension.

## **Professional Communities**

This section reviews the literature on professional communities, an overarching term I will use to encompass both communities of practice (CoP) and professional learning communities (PLCs). Due to the mandatory nature of participation in the community investigated in my study, I utilize the term PLC to describe it. However, when referring to both I will use the term professional communities, and when referring to communities of practice, I will use CoP. Additionally, I will use the designation of CoP when this is the terminology used by the researchers.

Jean Lave and Etienne Wenger first introduced CoP as a way of describing a space for professionals to come together and learn from one another, a place where members share common goals or interests and strive to understand and solve problems in their practice (Lave & Wenger, 1991). This premise, however, holds for both CoP and PLCs. In this review, I include studies on both types, as both bodies of research prove useful in informing the construction of my current study. Finally, I include the literature on professional communities because, like the last section on video, it further supports the need for teachers' reflective practice. This section contains three parts, first looking at communities of practice and then professional learning communities separately before narrowing the scope to look at them both within science education.

### **Communities of Practice in Education**

The use of a CoP has shown to support teachers learning new ways to teach. These communities aim to provide a safe and supportive environment to explore and process new ideas and ways of approaching teaching. A CoP allows teachers to access a larger knowledge and experience, providing them with multiple perspectives. Participants

initiate their membership by participating peripherally, learning by observing and discussing the actions of more skilled, confident members. As participants become more experienced members of the community, they are able to take over more central, leadership roles.

CoP as a construct redefines the way education looks at learning. It transforms the enterprise from an individual, decontextualized endeavor, with a specific beginning and end, to an everyday social experience. It also removes the idea that knowledge needs to be handed down from experts. Instead, CoP paints knowledge as constructed by learners themselves, aligning it with constructivist pedagogy (Wenger, 1998). Wenger (2011) describes CoP as “groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly” (p. 1). She lays out three crucial characteristics of CoP: domain, community, and practice. Participation implies a commitment and competence within the domain (which in this study is teaching) that distinguishes the participants from other people. Members of the community interact and learn from each other and develop a shared way of dealing with problems. They benefit from sharing resources, experiences, and tools with one another. Through their involvement in a CoP, teachers find support to assist in adopting new forms of practice.

The theoretical underpinnings of CoP are grounded in Lave and Wenger’s (1991) situated learning theory. This theory postulates that knowledge is created through reflection with others who have similar experiences (Buysse, Sparkman, & Wesley, 2003). Important in this theoretical framework is Edward’s assertion that knowledge is not “simply acquired, stored, and applied but rather something that is discursively

constructed and drawn upon” (as cited in Anfara & Angelle, 2008, p. 53). In sum, CoP portrays knowledge acquisition as an active, social endeavor.

Although more often studied within inservice contexts, the context of preservice methods courses fits perfectly with the defining characteristic of a group possessing similar experiences and interests. Investigating the applicability to preservice contexts raises research agendas such as: Do preservice CoP support growth in PCK by providing a non-threatening environment to discuss issues and problems and try out new skills? In what ways do CoP reinforce the active, communal nature of learning supported by research? CoP has proven useful in general education, and I believe this advantage may extend to science education including (and possibly especially) preservice contexts.

### **Professional Learning Communities in Education**

As mentioned previously, PLCs differ from CoP in that members do not initiate the affiliation. Their development stems from an outside body, such as administration, and as such participation is not voluntary. Professional learning communities, however, are built on tenets similar to CoP, “shared vision, purpose and trust” (Teague & Anfara, 2012, p.58), enabling them to rend sustainable changes as well.

“McLaughlin and Talbert (2006) define professional learning communities as “[organizational structures in which] teachers work collaboratively to reflect on their practice, examine evidence about the relationship between practice and student outcomes, and make changes that improve teaching and learning for the particular students in their classes”” (as cited in Teague & Anfara, 2012, p. 58). It is these attributes that I took into consideration in choosing a PLC structure as one of the selected scaffolds to explore in this dissertation. All of the factors of professional development discovered to affect



positively student learning are inherent in these communities (e.g., PLCs are cooperative, united, embedded in practice, and based on shared beliefs) (Hord, 1997; Marzano, 2003; Marzano, Waters, & McNulty, 2005). PLCs have been shown to encourage risk-taking and transform practice, possibly stemming from the effectiveness of non-evaluative feedback from peers (McLaughlin & Talbert, 1993). Additionally, the structure helps to transform how teachers frame learning situations taking place in their classrooms allowing them to change their focus to what is important (Richards, Levin, & Hammer, 2011). Lumpe (2007) summed up the process in the diagram displayed in Figure 1 (p. 127).

**The Process of Professional Development**

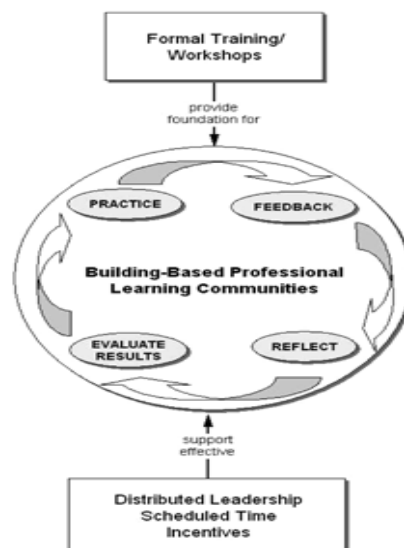


Figure 1. Displaying the interactive nature of professional development within a PLC. Reprinted from “Research-based professional development: Teachers engaged in professional learning communities,” by A. T. Lumpe, 2007, *Journal of Science Teacher Education*, 18(1), 125-128.

PLCs are widely accepted. They are condoned by organizations such as the Association for Supervision and Curriculum Development and the National Staff Development Council (Lumpe, 2007). PLCs help to develop an atmosphere of collegiality that can be carried into the preservice teachers’ professional life to encourage

continual professional growth. Furthermore, PLCs fit the Deweyan model of learning “where teachers engage in collective inquiry in order to weigh their practices and innovations against empirical evidence and critical dialogue” (Wood, 2007, p. 282), casting teachers as not just users but creators of their PCK. This model aligns closely with constructivist theory in that it focuses on teachers building their own understandings. Finally, these communities mirror the trajectory of learning recommended for effective science learning/teaching.

Even though incorporating PLCs into districts has shown to be more apt to rend systemic change, due their democratic underpinnings, a paradigm shift is needed in order to embrace a new vision of the role of teachers in education. This new role extends their sphere beyond standing in front of a class (Hord, 1997).

### **Professional Communities in Science Education**

Science education has adopted the use of professional communities as a way to combat the ineffectiveness of one-shot workshops and to overcome the traditional isolation of classroom teaching for inservice teachers. Lumpe (2007) discussed the ineffectiveness of isolated professional development programs, declaring them a waste of millions of dollars. He cited research by Marzano and colleagues (2003, 2005) that listed integral factors in facilitating student achievement: “effective feedback, cooperation, collegiality, practice-oriented staff development, a culture of shared beliefs and relationships” (p. 125). These ideals, often missing from isolated workshops, are fostered by PLC. Because teachers’ careers are usually spent primarily in isolation, they seldom are given a chance for meaningful collaboration that could help focus them on student learning and expand their thinking and therefore their approach to teaching.

Unfortunately, school districts rarely have structures in place to facilitate these types of communities. However, when professional development is delivered in a site-based context and situated within this type of collaborative environment where teachers are focused on meaningful content, research has shown student learning can be cultivated. Additionally, professional communities allow preservice teachers to participate in a group that acknowledges their role as educators. Finally, these communities help preservice teachers bridge practice with theory and furnish them with a system of support and inspiration.

The collaborative nature of learning fostered by professional communities can help to build and hone teachers' subject matter knowledge. Grossman, Wilson and Shulman (1989) proposed that subject matter, unfortunately often overlooked in considering teacher professional growth, is of prime importance. The lack of subject matter knowledge is especially relevant for elementary educators because they are responsible for such a wide range of disciplines. Additionally, elementary teachers face being assigned to a range of grade levels, significantly expanding the scope of subject matter knowledge needed. Research points to the efficacy of utilizing professional communities to support teachers in combatting this problem. For instance, Akerson, Cullen, & Hanson (2009) presented findings from a twelve-month professional development featuring a CoP that included seventeen K-6 grade teachers. The researchers investigated how to improve the teachers' views of nature of science (NOS). The teachers' struggles in attempting to teach NOS concepts paired with opportunities to discuss these struggles within their CoP facilitated awareness of their own views. The researchers found that participation in the CoP was not enough to improve teacher

knowledge and/or practice. They bolstered support through modeling and explicit reflection. (My study utilizes a content specific moderator to provide this extra guidance.) The researchers enhanced the CoP by having teachers participate for two weeks in an intensive summer workshop in addition to monthly workshops held at the school sites. The support lent to learning subject matter is one of many practical gains professional communities provide.

The practicality of professional communities seems especially relevant for preservice and novice teachers. A majority of participants responded positively to questions about engagement in a CoP in Leite's (2006) study examining the views of 46 prospective physical science teachers. They saw the CoP as a solution to their institution's focus on academic knowledge at the expense of experiencing practical applications. The preservice teachers felt that their current program did little to address issues related to the context of their future careers. Additionally, the majority of participants cited concerns about their future integration into school culture. Leite supported his assertion with this quote from Meyer: "novice teachers need opportunities to talk with others about the teacher they want to be, given the students they teach and the context within which they work" (as cited in Leite, 2006, p. 7). He also connected the issue with Verloop, Van Driel, and Meijer's (2001) conception of practical knowledge. In Leite's (2006) study, the preservice teachers saw peer input as highly useful to their growth as educators. The results of the study showed that although preservice teachers gave university supervisors and mentors high ratings, they assigned their own colleagues the very highest ratings when considering the contribution of different individuals to their learning. Characteristics of a CoP that preservice teachers found desirable were

organization, productivity, and open-mindedness of members. The participants who indicated that they would like to be part of a CoP saw sharing common experiences and cooperative problem-solving as important benefits. These interactions were perceived by preservice teachers as important for their PCK development.

In science education, professional communities provide a forum for building subject matter knowledge. The lack of subject matter knowledge comprises an obvious barrier in understanding student thinking and deciding how to tailor curriculum to improve students' conceptual understandings. If a teacher does not understand the material themselves, they will not be able to probe and guide student thinking appropriately. The supportive nature of CoP can assist preservice teachers in developing solid conceptual understandings of scientific subject matter and help them to build pedagogical strategies for conveying this knowledge to their students. Models of professional communities such as CoP or PLCs help to extend learning, connect practice to theory, and provide the milieu for brainstorming ideas and gathering resources.

### **Content Specific Moderator as Coach**

In addition to video as a tool for reflection and the use of a professional community for supporting collaborative reflection on the video, my study will include a content specific moderator, a role that I will assume, to guide the PLC's reflection process. The moderator will serve as an instructional coach for the community to support the development of the preservice teachers' skills to notice professionally students' science thinking as a way to inform their instructional decisions. The coaching literature serves as the basis for crafting the parameters of this role.

Coaching is defined as classroom-based support provided by an individual knowledgeable about both content and pedagogy. This support strategy provides a structure to model research-based strategies and help facilitate teachers in learning how to incorporate these strategies within the context of their practice. The literature points to positive effects on practical knowledge, domain knowledge, and teacher efficacy as well as improved practices in writing instruction, across such fields as special education, mathematics education, and preservice teacher education in general (Cantrell & Hughes, 2008; Sailors & Shanklin, 2010; Staub & Stern, 2002; Zwart, Wubbels, Bolhuis & Bergen, 2008).

Additionally, research has pointed to coaching as useful in scaffolding professional noticing. As preservice teachers are asked to teach in ways that they did not themselves learn, the use of a coach to assist in tying theory to their specific practice becomes invaluable (Darling-Hammond & McLaughlin, 1995). The institution of coaching, although employed initially within the educational spheres of literacy, is assumed to extend to other spheres by researchers studying models of coaching (Heineke, 2013; Knight, 2007).

Recent studies point to the effectiveness of coaching in supporting teachers to incorporate new classroom practices (Heineke, 2013) For example, Walpole, McKenna, Urive-Zarain, & Lamirina(2010) demonstrated the viability of utilizing a coaching model to create changes in literacy practices such as regular inclusion of read-alouds, differentiated small group instruction, and use of grade appropriate materials. Neuman and Wright (2010) also investigated the effect on literacy instruction and suggested that coaching yielded “statistically significant improvements in structural environments both

immediately and 5 months later” (p. 63). By “structural environments,” the researchers referred to the quality of instructional supports instituted by the teachers. In Sailors and Price’s (2010) study of 44 teachers, the researchers found that the addition of coaching to workshop-based professional development increased self-efficacy beliefs for reading instruction.

The rationale for employing a coaching model to mediate learning in the professional communities formed for my study is the balance that I believe this model offers between facilitator-lead and participant-owned communities. As previously stated, the focus of this study is to learn how having preservice teachers reflect on video of their own teaching will help develop their ability to professional notice, as well as support the development of their PCK readiness. I contend, given what the literature says about preservice teachers’ tendencies to focus mainly on classroom management when reflecting on practice (Appleton & Kindt, 2002), that employing a coaching model within the context of professional communities may provide the supports necessary for preservice teachers to develop the skills for professional noticing, a critical component of their PCK development.

However, as Thompson (2005) discussed, there is a fine line between providing a supportive environment and providing too much structure. Therefore, as a content-specific moderator, or content coach, for each professional community (large group and small group) established in this study, I will need to ensure that my position in the community is viewed by the others as a resource rather than the director of the learning. This is not to say that I will not ensure member behaviors remain on task so that they do not become distracting to the functioning of the community. But I will also be looking for

ways to build autonomy within each community so that the preservice teachers begin to take ownership in the reflection and decision-making process. In other words, the coaching model I expect to follow is similar to what Thompson (2005) terms a “virtuous circle” (p. 152). In this model, greater participation by all members yields greater learning. For this greater participation to occur, members must progress from the periphery to the center of their community’s structure. In doing so, they become motivated to take on leadership roles that can benefit the actions of their community. This idea of moving the preservice teachers from a peripheral level of participation to core participation relies on my ability to scaffold, and notice the right times to remove scaffolds, so that acts of reflective practice in each community are driven by evidence of the preservice teachers’ readiness to push their own professional noticing, and thus their PCK for teaching science.

### **Gaps in the Literature and Contributions of this Study**

From my review of the research on general and video-based reflective practice, professional communities, and coaching, I found positive reports on each of these approaches individually contributing to teachers’ abilities to professional notice. However, there is limited literature on the combination of these practices, and no literature on the possible benefits of combining all three within the context of preservice science teacher preparation and the effect that the combination of all three approaches may have on developing skills for professionally noticing to support PCK readiness. It is this gap in the literature to which my study will contribute.

Although there is a significant body of educational research on the use of video with preservice teachers for the purpose of reflecting on others’ teaching (Abell & Bryan,



1997), having preservice teachers use video of their own teaching to reflect on and inform practice is limited (Nilsson, 2008 ; Wiebke, Park Rogers, Nargund-Joshi, & Akerson, 2012). The promising aspects of having preservice teachers reflect on their own and their peers' teaching include the removal of the vicarious nature of reflection provided by canned video and the placement of teaching within the context of their zone of proximal development. Therefore, the benefits of using preservice teachers' own teaching videos for the purpose of reflecting on practice and developing their professional noticing is a critical gap in the literature that needs to be addressed, especially within the sphere of science education.

Professional communities have also been investigated more widely in inservice situations, so their use in preservice contexts would benefit from additional investigation. My research could inform what is useful at the preservice stage of development to promote reflective teaching. This might move reflective practice “from a general, widely used slogan to a practical working principle” (Calderhead, 1989, p. 49) in science education. By continuing to challenge and revise our thinking, the science education community can develop more detailed and varied lenses with which to examine and understand how professional communities work with novice teachers, which in turn will provide important insights into promoting novice teacher development.

The lack of research situated within the context of science teacher education is also true for the educational coaching literature. Similar to what was found in the literature on using video for reflective practice and forming communities to support professional learning, the literature on coaching has mostly focused on its use within inservice contexts. Also, within this context it has been used mainly for the purpose of

improving the teaching of language arts (reading and writing). There has been a recent rise in the number of studies on mathematics coaches, but within the field of science education the use of coaches to support instructional decision-making is scant.

Considering each of these gaps in the literature, it leads one to wonder, can a combination of these approaches support elementary preservice science teachers in developing the ability to notice professionally, and thus also support their PCK readiness? I believe that my study has the potential to contribute significantly to this question, thus affecting what the field of science education knows about what can be developed as well as how to scaffold the development of novice teachers' PCK for teaching science.

## CHAPTER 3

### METHODOLOGY

#### **Research Tradition**

The purpose of this study was to discover how a combination of scaffolds consisting of video-based reflection on practice, a professional learning community, and a content specific moderator as a guide can be embedded into a methods course to support preservice teachers' learning to professionally notice elementary students' scientific thinking in order to provide a responsive curriculum. The study was designed on the premise that the skill of professional noticing is critical for preservice teachers to acquire the knowledge and ability to develop their personal PCK and topic specific professional knowledge. The study was situated in the context of a methods course as the structure provided within teacher education programs to tie theory to practice. This context also naturally supported the role of a content specific moderator as it is uniquely tailored to the skill set of a methods instructor.

A qualitative methodology guided this study because, as Merriam (2009) observed, qualitative research examines "how people make sense of their lives and their experiences" (p. 23), and the goal of this study was to capture preservice teachers' experience of learning to professionally notice students' thinking in order to provide a responsive curriculum. She also pointed out that constructivism, one theoretical basis of qualitative research which seeks to understand how individuals "construct reality within their social world," (Merriam, 2009, p. 22) correlates with the study of participants building their understanding of how to teach using student thinking to guide curricular decisions with the support of the PLC. Given that my study seeks to understand how

preservice teachers construct an understanding of professional noticing and apply this knowledge to designing a responsive science curriculum, both individually and in collaboration with others, the use of a qualitative method best fits the purposes of this study. More specifically, I selected a case study design to guide my investigation. I describe my rationale for this choice in the section below.

### **Qualitative Case Study Design**

As Patton (2002) explains, qualitative research design often involves three strategies: naturalistic inquiry, emergent design flexibility and purposeful sampling. This study drew on all three strategies for its implementation. It a) was situated within a methods course, a natural setting for learning about teaching and learning (naturalistic inquiry); b) included the use of PLCs (both small group and whole class), allowing each to take on its own identity according to the group members' needs and how their understandings emerged, and requiring me to be flexible by modifying the design and implementation of the scaffolds I used in the study (emergent design); and c) selected individuals to interview to gain a clearer, more detailed understanding of their responses on two pieces of data collected (purposeful sampling).

More specifically, because this study was situated in an elementary science methods course, the whole class constituted a case for study. Case study research is empirically-based research on how a particular phenomenon is experienced within a real-life context (Merriam, 2009). In this case, the phenomenon under investigation was professional noticing for the purpose of providing a responsive curriculum within the context of elementary preservice teaching. Additionally as in a classic case study format, the researcher constituted the primary instrument for data collection, and data was

analyzed inductively to produce a richly detailed description of the phenomenon. Accordingly, I acted as both researcher and participant, becoming part of the process being examined and immersing myself within the experience in order to provide richness of description and understanding (Sofaer, 1999).

### **Research Questions**

Given the aim of this case study to examine whether and how three scaffolds (video-based reflection, use of PLCs, and a content-specific moderator) can support preservice elementary teachers' learning to professionally notice students' scientific thinking and design a responsive curriculum, the following research questions were addressed:

1. How do the abilities to professionally notice students' scientific thinking develop as preservice elementary teachers in this study participate in a four-week, moderator-led, professional learning community (PLC) featuring video-based reflection on practice, and to what aspects of the three scaffolds do participants attribute this development?
2. How do the participants use what they have learned about student thinking to modify their instruction, and to what aspects of the three scaffolds do participants attribute this change?
3. In what ways does the combination of the three scaffolds (i.e. the intervention) set within the context of a methods course affect participants' development of their personal PCK and topic specific professional knowledge?

## **Research Design**

This section is divided into four subsections: context, participants (including the role of moderator/ researcher), data collection, and data analysis.

### **Context**

A single section of an elementary science methods course constituted the case for this study. The course was the second of three professional clusters of coursework in the elementary teacher education program at a large Midwestern state university. Most students in this course were in their junior year of the teacher education program. In this cluster, the preservice teachers were taking a special education course, two methods courses -teaching elementary mathematics and teaching elementary science, and an early field experience course in a local elementary school shared by the math and science methods courses. As part of this cluster, the preservice teachers designed and taught two series of five lessons, one for math and one for science. The focus of this study is on the science teaching portion, which occurred in the final five weeks of the semester.

The preservice teachers were organized into teaching teams of four or five and together designed a five-lesson mini unit on a topic selected by their cooperating classroom teacher. The field experience used an iterative approach, described by Weiland, Hudson, and Amador (2014) as one that “focuses on eliciting students’ mathematical and scientific thinking... to provide preservice teachers with close interactions with elementary students and to allow them to develop personal models of student reasoning” (p.330). With guidance from their methods instructor, the preservice teachers created a unit matrix to sequence the progression of ideas in their unit. They were given time and resources both within and outside of class time to plan the unit with

their team. See Table 1 for an overview of the grade levels and topics covered for each group per week. Given my interest was to explore how the preservice teachers learned to professionally notice student thinking and then modify instruction based on what they learned from noticing, I focused on the five weeks they were actually teaching in the field and not on preparation that occurred prior to the teaching. However, I collected copies of the final set of lesson plans that their methods instructor approved for each team to serve as a basis for gauging their thinking prior to teaching and documenting instructional changes made from week to week.

Table 1  
*Grade Level, Topic and Sequence of Lessons by Group*

Group # Grade & Level Main Topic	Topic by Lesson
1. Grade 5 Conservation of Matter, Mass/Volume Relationships*	1) weight and volume 2) weight and volume 3) weight volume and mass 4) Measuring weight volume and mass 5) Lesson on conservation of matter replaced by application lesson
2. Grade 2 Motion	1) Introduction - How objects move 2) Forces – Pushes and Pulls 3) Why do objects stop moving? 4) Friction 5) Lesson on gravity replaced by application lesson
3. Grade 3 Light	1) What is Light? 2) How light travels through different mediums – shadows 3) Light spectrum(the portion on wavelengths was removed) 4) Refraction 5) Reflection (Due to time constraints the methods instructor worked solely with this group during the 4 <sup>th</sup> PLC. She did not push them to create an application for the final lesson.)
4. Grade 3 Light	1) How Light Travels 2) Refraction 3) Reflection 4) Shadows 5) Lesson on light sources replaced by application lesson

\* Grade 5 lessons changed the most due to their students not attaining the concepts. This group never got to conservation of matter. The originally planned concepts are listed below.

- 1) Differences between weight and volume
- 2) Measuring weight and volume
- 3) Weight Volume and Mass
- 4) Conservation of Mass in relation to weight and volume
- 5) Conservation of Matter – Changes in State

## Participants

The participants included the entire population of preservice teachers enrolled in one section of the elementary science methods course, the methods course instructor, and myself as researcher- participant in the role of content specific moderator. The preservice teachers were divided into teaching teams of four or five members for the purpose of their field experience, designated as professional learning communities (PLCs)<sup>1</sup>. In the methods course, these communities supported participants' video-based reflections of their own and their peers' teaching. As content specific moderator, I worked with each teaching group PLC as well as the whole class PLC to guide the preservice teachers through the reflection process. Therefore, in addition to the students, I was a member of each group's PLC and the whole class PLC. The methods instructor, in addition to helping tie the theory learned in the methods course to practice, participated in the PLCs as well, providing groups with the benefit of her PCK as an experienced teacher. The whole group portion helped to develop a common discourse and model the process of noticing and reflecting on student thinking with the use of video.

The majority of data collection occurred over seven weeks, beginning with a few short visits: a) an introductory meeting with the preservice teachers (20-30 minutes, where I explained the purposes and procedures of the study, explained the format of the scaffolds, and collected consent forms; and b) a modeling meeting (15 minutes), at which I modelled the video selection and reflection process that were used each week.

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<sup>1</sup> This notion of assigning participants to groups is the reason why the term professional learning community rather than community of practice was selected for describing the kind of group collaboration used in this study. Generally, communities of practice form naturally, based on participant motivation stemming from common goals or needs, whereas a professional learning community may be formed purposefully according to grade levels or subject areas to reflect on or address a problem of practice with shared leadership and direction from administration (Teague & Anfara Jr., 2012).



Following these informational sessions, we will began the series of four weekly content-specific moderated PLC sessions using video as a tool for reflection, at which I served as the lead facilitator with the participation of the methods instructor. These sessions were held in the methods class from 11am to 12:15pm each Wednesday, to discuss the previous week's lesson and plan for the next one. Because the fifth lesson was taught during the last week of classes, we reflected on that in their field placement immediately following their teaching. I had the preservice teachers' video record this lesson as well as their final lesson study meeting to use as evidence of progression in their noticing skills, personal PCK, and topic specific professional knowledge. During this meeting in the field they reflected on the intervention in general, both individually in written form and orally with their group as well as selecting portion of the video to watch to practice and demonstrate their noticing skills one more time.

**Balancing my role as both moderator and researcher.** Being the content specific moderator of the PLC cast me in a double role as both participant and researcher; allowing me to fully experience participation within the community but also risking bias in my analysis of the data. Therefore, I strove to recognize and bracket my biases, as Starks and Trinidad (2007) explain, by being “honest and vigilant about [my] ... own perspective, preexisting thoughts and beliefs... [enabling me to] recognize and set aside [but not abandon].. ... [my] a priori knowledge and assumptions, with the analytic goal of attending to the participants' accounts with an open mind” (as cited in Tufford & Newman, 2012). So although I had to be vigilant to bracket my biases, being a researcher/participant provided me with an intimate perspective on the experience by situating me within the community.

## **Data Collection**

I collected data from multiple sources to answer my three research questions. To map which source or sources were used to answer each question, I prepared a data collection and analysis matrix (see Appendix B).

The first sources of data were two survey instruments administered by the methods instructor to provide formative assessment for the course. One, the Demographic Survey, elicited preservice teachers' prior experiences with and beliefs about learning (and possibly teaching) science (see Appendix C). The other instrument, entitled Lesson Design Task Survey, presented a scenario about designing a third grade introductory lesson on light, followed by 10 questions about how the preservice teachers would go about planning this lesson (see Appendix D). The first survey provided information on each participant's orientation towards learning and teaching science (e.g., what they viewed as the goals and purposes of learning and teaching science). I also received some information about each participant's science content background, which helped me understand their science learning experiences. The Lesson Design Task provided preliminary information as to how participants thought about planning for teaching science. Additionally, I purposefully selected six participants based on their survey responses in order to be interviewed for more information on their responses to the lesson planning scenario (see Appendix E) and the Demographic Survey. Questions asked about the Demographic Survey were based on participants' responses to original questions and therefore did not follow a specific protocol (see Appendix M for timeline of specific dates of pre, post surveys and their follow up interviews).

The data from the pre-surveys and their follow up interviews assisted me with addressing my third research question about the preservice teachers' development of personal PCK and topic specific professional knowledge, as well as beliefs that might amplify or filter their growth. They also provided a baseline understanding of participants' thinking about planning science instruction before they experienced any of the scaffolds I planned to implement with them.

The two surveys sources were also collected near end of the semester as part of the regular science methods course (see Appendices C and D). At that time I contacted the students I had interviewed initially again and used the interview protocol (Appendix E) to probe their decision-making processes for planning the lesson. I based follow up interview questions for the demographic survey (see Appendix C) on participants' written responses. These post surveys and interviews provided information on the preservice teachers' PCK development. The post surveys and interviews (see Appendices C, D, and, E) included additional probes related to the scaffolds I implemented in order to elicit the aspects to which the preservice teachers attributed their decision-making while planning lessons and also their current modified set of beliefs about science teaching and learning. These post surveys and interviews also informed Research Question 2 in that they addressed how participants based instructional decisions on what they learned from noticing as well as elements of the intervention to which they attributed changes. The post interviews also informed Research Question 1 about the development of their abilities to notice and aspects of the scaffolds to which they attributed changes.

Finally, the data relevant to Question 2 related to modifying instruction are concentrated in the last two items of the Demographic Survey (see Appendix B) and

question #8 on the Lesson Design Task (see Appendix C) as well as in the follow up interviews. As previously indicated, the two survey instruments (both pre and post) were collected by the science methods instructor for the purpose of formative assessment and course feedback, and I was granted access to these completed by the preservice teachers who consented to participate in this study.

From Canvas, the online methods course site, I also had access to all teaching groups' science unit lesson plans prior to teaching as a baseline for comparison with their final revisions lessons after they had taught and met in their group PLCs to modify their existing plans based on their reflections on their students' thinking. I also video recorded the first 30-minute meeting to explain the PLCs and the progression and protocols of the study, and the second 15 minute meeting to model the video-based reflection on the professional noticing process and set up norms for the PLCs. These data documented the initial stages of participants' development as well the early stages of the three scaffolds, allowing me to begin the continuous process of evaluation and modification. These two meetings (see appendix M for specific dates of these meetings) were held during the regularly scheduled methods class. However, due to time constraints, little useful data were collected during these meetings.

Because as moderator I could not provide each of four groups the same amount of one-on-one attention as I gave to the single group in my original study, I instituted the following sequence to support the whole class in developing their noticing skills. A member of each teaching group video recorded their lesson taught on Thursday and I uploaded it by Friday to be reviewed by all group members individually using a provided protocol that focused their attention on noticing, which they used to write reflections to

be submitted to Canvas the following Monday (see Appendix G Individual Video Viewing and Written Reflection). Each also chose a short clip highlighting an incident of noticing to share with group members during the PLC meetings (see Appendix H for example of PLC agenda), which were held during the second regularly scheduled methods course session (Wednesday) for four consecutive weeks with a break for Thanksgiving. (see Appendix M for timeline of study and Appendix F for sample weekly schedule).

As the written reflections were submitted via the online learning site for the science methods course, making them available to both myself and the methods instructor, they substituted for the reflective teaching blog required by all the other sections of this course. The data collected from this source provided a record of how the preservice teachers' abilities to notice developed as they progressed through the four-week intervention, addressing Research Question 1. These posted reflections also documented how the participants' beliefs affected the growth of their personal PCK and topic specific professional knowledge.

Every Wednesday both small group and whole class PLCs met for the entire methods course time slot of 75 minutes (see Appendix H for sample PLC agenda). Except the last 10 minutes when preservice teachers were completing written exit slips, these meetings were video recorded.

The first part of the session when small group PLCs met to reflect on the members' selected clips was guided by a provided protocol (see Appendix H -Teaching Group PLC video reflection) and the modeling I had provided prior to their first lesson reflection. As content specific moderator, I circulated among the groups, observing their

process and probing and pushing their thinking about professional noticing, using questions from the CoRe Protocol (see Appendix I - Sample Questions asked by moderator during Teaching Group PLC session video reflection). Data from this part of the PLC informed Research Question 3, concerning the development of participants' personal PCK and topic specific professional knowledge.

At first, the second part of each weekly PLC meeting entailed a whole-group, moderator-led reflection on clips selected by the moderator from a different teaching group each week. We began with the CoRe protocol questions mentioned above (see Appendix I -whole group PLC session-video reflection) to provide a context for viewing the video clips and to model PCK considerations that preservice teachers should take into account. As content specific moderator I then guided the group in reflecting on the video, modeling call-out procedures and ways to stimulate increased attention to student thinking, in order to scaffold the preservice teachers in noticing elementary students' scientific thinking, as well as in practicing professional community etiquette. This whole group session provided a cohesive modeling and scaffolding experience for the group while helping to build a common discourse and facilitate a supportive ethos in the larger community.

By the end of the second PLC, however, I realized that this whole group portion was not benefitting the community in the ways I had originally intended, so I modified the second half to focus the participants on what to do with what they had noticed about students' thinking. The new protocol asked the teaching group PLCs to discuss the main issues they noticed in the last lesson and consider how they could address these issues before discussing how to modify the next lesson. This process was then followed with a

whole group sharing of issues participants identified (see Appendix K for the New Protocol and Focusing Questions). The new whole group format provided data for answering Research Question 2 related to how and why they modified their next lesson the way they did.

All sessions described above were video recorded, and I reviewed the video data iteratively. The lesson modification portion informed both Research Questions 2 and 3 as this part of the PLC focused on how participants applied what they learned about student understanding to modify their next lesson as well as demonstrated progression in their personal PCK and topic specific professional knowledge, so progression in their orientations also emerged. In a related modification, after the second PLC, the original format, in which the whole group portion of the meeting was followed by teaching group meetings to modify their next week's lesson, was changed so that time for participants to modify the next lesson was combined with additional focused time for reflection (see Appendix K for the New Protocol and Focusing Questions).

Finally, students responded to one or two exit slip questions at the end of each Wednesday class (see Appendix I Sample Exit Slip Questions). These short in-class writings captured reflections on issues concerning beliefs and orientations to teaching/learning science modified from Luft and Roehrig 2007 not covered in class due to time constraints. I also used the exit slips to inform me of what participants thought about various parts of the PLC, what their understanding of noticing and the 5Es was, and what they thought were the points of major significance within the intervention.

PLCs one and two yielded five sources of data 1) written reflections of individual viewing of entire video recorded lessons; 2) teaching group discussion of selected clips;

3) whole group meeting to reflect on moderator chosen clips; 4) teaching group meeting to modify the next lesson; and 5) written exit slips. Video data was collected for both the teaching and whole group portions of the PLC.

After the second PLC, the meeting protocol was modified so for the PLC three and four the first two sources listed above written reflection and teaching group discussion of clips were followed by a focused reflection time which lead into the lesson modification time before the whole group sharing of what was discovered during these reflections time and how they used that information to guide their next steps. And finally as with PLC one and two, the meetings end with completing written exit slips.

Because as noted above the fifth lesson was taught during the last week of classes, a modified reflection was held at the field placement site, during which the participants watched selected portions of their lessons and discussed attention to student thinking. They also reflected on the intervention both orally and in written responses referred to as the Final Survey (see Appendix L for the Last Meeting Agenda and Final Survey Questions), which informed Research Question 1.

Finally I kept a researcher/content specific moderator journal, in which I recorded my thoughts on all aspects of the research process, including my reading through the two methods course surveys, conducting the follow up interviews, reflecting on the two introductory meetings, watching the video of each preservice group's weekly teaching, and selecting clips to use in the whole group PLC video reflection. I also recorded my thoughts and ideas after reading through the individual video reflections and after each of the four PLC meetings. Thus this journal informed Research Questions 2 and 3.



Additionally the journal helped me bracket my biases and served as a formative assessment tool when I modified the protocols to address the needs of the community.

### **Data Analysis**

Data were examined for each research question specifically. I used open coding to determine emergent themes in all written data: the two surveys (Demographic and Lesson Design Task) collected as part of the regular methods curriculum, the individual written reflections, the exit slips, the researcher/moderator journal, and the final survey. I employed the iterative coding procedure of grounded theory. As themes emerged for each piece of data, I compared them with the themes from other sources in order to determine overarching patterns as well as possible variations.

All interview data, including follow-up to the two surveys and both pre and post interviews were transcribed and similarly coded, using an open coding format before iteratively reviewing the interviews separately to identify emerging themes and patterns as well as variations across the participant responses, which I then compared with themes from other data sources.

I reviewed the three video recorded sections of the PLC, as well as the video footage of the two introductory meetings iteratively, creating video logs with time stamps. I used these logs, along with further review of the actual footage, to identify codes and form themes relevant to each research question. Themes from different data sources were continuously compared in order to discover nuanced meanings to answer the research questions posed and to validate findings through triangulation. Timestamps were useful for marking where to go in order to view a specific clip or transcribe important sections

of dialogue to exemplify my final themes. In the following section I further discuss data analysis by research question.

For Research Question 1, “How do the abilities to professionally notice students’ scientific thinking develop as the preservice elementary teachers in this study participate in a four-week, moderator-led, professional learning community (PLC) featuring video-based reflections on practice, and to what aspects of the three scaffolds do participants attribute this development?” I began data analysis by reviewing all data sources relevant to this question. These included the video of the preliminary modeling meeting, videos of the noticing portion of PLCs 1-4, individual written reflections on each group’s videos of lessons 1-4, and my researcher/moderator journal to bracket my findings. Although I had reviewed all the data previously to form a general picture of the participants’ progression in learning to notice, when closely analyzing the data, I discovered that the individual reflections 1-4 was the source that provided the information I needed to answer the first part of the first question 1, as this data source not only included the clips chosen to reflect their knowledge of how to recognize critical incidents, but also the degree to which they analyzed students’ thinking and the responses they suggested. I first made paper copies of all electronic entries submitted for lessons 1-4 as part of their methods course requirements. This assignment was the equivalent of a weekly reflection blog completed by the other sections of the methods course. After applying open coding and identifying themes and patterns in their progression, I applied van Es’ framework (2011) to the themes to gauge the level of noticing attained. My analysis was two-pronged, focusing on what teachers noticed and how they noticed. I was able to discern themes for each element of the van Es framework (see Table 2).

For the second part of Question 1, referring to aspects of the scaffolds to which participants attributed their changes in noticing skills; I started with analyzing the transcribed follow up interviews using an open coding format to identify changes attributed to each of the three scaffolds as well as to those attributed to their combined effects. These interviews were especially helpful in that I could ask participants directly about what scaffolds were helpful and why. I also analyzed exit slips 1 and 4 and the final surveys in the same manner, extracting themes for components first individually and then in combination. Both of these sources allowed me to ask participants specifically about how they credited their changes. Finally I looked across all the data sources to compose a rich description of the aspects of the scaffolds to which changes in noticing abilities attributed.

For Research Question 2, “How do the participants use what they have learned about student thinking to modify their instruction, and to what aspects of the three scaffolds do participants attribute this change?” I first applied open coding to the post demographic survey and the post lesson design task, as well as to the transcribed follow-up interviews, identifying themes related to the question. I iteratively watched videos both of the teaching groups’ noticing portion of the PLC and of the whole group reflecting on video clips of their teaching lessons 1-4 pulling from the whole group sharing portion of PLC 3 to illustrate themes found. I created time stamped video logs which I inductively coded. Additionally I used open coding to pull from exit slip 1. Finally I applied open coding to my researcher/ moderator journal to find emergent themes relating to the participants’ use of knowledge of student thinking to modify instruction. I then compared codes from all data sources with the lesson plans they turned

Table 2  
*Framework for Learning to Notice Student Scientific Thinking*

Modified from: Framework for learning to notice student mathematical thinking (van Es, 2011, p.139)

	Level 1 Baseline	Level 2 Mixed	Level 3 Focused	Level 4 Extended
What Teachers Notice	Attend to whole Class environment, behavior, and learning and to teacher pedagogy	Primarily attend To teacher Pedagogy  Begin to attend To particular Students' scientific thinking and behaviors	Attend to particular students' scientific thinking	Attend to the relationship Between particular students' scientific thinking and between teaching strategies and student scientific thinking
How Teachers Notice	Form general impressions of what occurred  Provided descriptive and evaluative comments  Provide little or no evidence to support analysis	Form general impressions and highlight noteworthy events  Provide primarily evaluative with some interpretive comments  Begin to refer to specific events and interactions as evidence	Highlight noteworthy events  Provide interpretive comments  Refer to specific events and interactions as evidence  Elaborate on events and interactions	Highlight noteworthy events  Provide interpretive comments  Refer to Specific events and interactions as evidence  Elaborate on events and interactions  Make connections between events and principles of teaching and learning  On the basis of interpretations propose alternative pedagogical solutions

in to the methods instructor before teaching in order to understand the progression of their abilities to modify instruction based on knowledge of student thinking.

To analyze the second part of question 2, addressing the aspects of scaffolds to which participants attributed changes in their ability to modify curriculum based on students' thinking, I applied open coding to the post demographic and lesson design task surveys, transcripts of the follow up interviews, and exit slips because these documented the changes in the participants' own words. Then I iteratively reviewed the video of lesson modification sessions during PLC 2 to make video logs marking applicable areas designating themes pertaining to scaffolds that helped participants learn to modify their curriculum based on student thinking. Finally, I coalesced the themes under each of the scaffolds separately as well as those attributed to the combination of all three.

For Research Question 3, "In what ways does the combination of the three scaffolds set in within the context of a methods course affect participants' development of their personal PCK and topic specific professional knowledge?" I organized my analysis into three sections: how scaffolds affected PCK development, how changes in beliefs about teaching science affected this growth, and how changes in beliefs about using noticing to inform practice affected this growth.

I initiated my analysis by applying open coding to the post demographic and lesson design task data to determine the level of participants' knowledge about teaching and lesson design near the end of the intervention. Additionally I coded transcripts of the post interview, to analyze answers to my specific questions in their own words, and the PLC lesson modification video, to analyze the participants' solutions as well as their reasoning behind their decisions. I reviewed the footage iteratively, creating time

stamped logs to mark places that contained dialog relevant to the question. Finally I integrated codes from all data sources to depict a rich, detailed overview of how the scaffolds supported the preservice teachers' PCK development.

### **Trustworthiness**

I utilized triangulation of multiple data sources and bracketing of my biases via my researcher journal to ensure the trustworthiness of my results. Additionally the grounding of my data collection and analysis on my previous study as described in Chapter 1 supports the reliability of this study (Yin, 1994).

The prime method for ensuring trustworthiness was drawing from multiple data sources to triangulate my data and confirm emerging findings. Finding the same results (i.e. similar themes) from different data sources also increased the likelihood of transferability of my findings. For each question I used information from a variety of sources in order to form a rich thick description, allowing readers to find relevance to their own particular contexts (Merriam, 2009).

Another a main strategy to ensure trustworthiness was using my researcher/content specific moderator journal to bracket my biases and compare these with my coding from other data sources to identify potential preconceptions. The researcher journal meticulously documented my experiences and changes in my perspective while guiding the PLC sessions within the context of a methods course. Additionally it served to examine and help bracket my biases.

Finally grounding my data collection and analysis on my previous study gave insight and validation for findings uncovered.

## CHAPTER 4

### FINDINGS

As outlined in Chapter 1, this study examines the effects of a three-pronged scaffold consisting of video-based reflections on practice, professional learning community participation, and a content specific moderator on preservice teachers' learning to notice and respond to students' scientific thinking. The three research questions provide the organization for this chapter. Question one examines changes over time in the range of participants' abilities to notice. Question two investigates the modifications they made to their initial plans based on what they noticed. Question three addresses the development of participants' personal PCK and topic specific professional knowledge for teaching science during the four-week intervention. The whole class is considered a case, but individual examples are provided to illustrate themes that emerge, and variations in participants' ability to notice are discussed.

The first section of this chapter is subdivided to address various components of the first research question. The first level of division includes what the participants noticed, how they noticed it, and to which of the scaffolds they attributed the progression of their noticing skills. The analysis of *what* preservice teachers noticed follows the four levels of the van Es (2011) framework: Level 1: the whole class's environment, behavior and learning, and teacher pedagogy; Level 2: the teacher's pedagogy and attending to students' thinking; Level 3: particular students' thinking; and Level 4: the relationship between students' thinking and the teacher's strategies. With regard to *how* the preservice teachers noticed, there are also four levels: Level 1: forming general impressions, providing descriptive or evaluative comments and providing little or no evidential support; Level 2: providing general impressions and highlighting noteworthy events,

providing evaluative and some interpretive comments, as well as beginning to refer to specific events and interactions; Level 3: continuing with highlighting noteworthy events, providing interpretive comments, referring to specific events and interactions, but also elaborating on the events and interactions with respect to student thinking; and Level 4: making connections between events and principles of teaching and learning on the basis of interpretation, and proposing alternative pedagogical solutions in addition to all of the elements included in Level 3. Changes attributed to scaffolds are described separately first and then in combination.

In addition, I included another layer of organization according to the preservice teachers' initial abilities and their near end abilities to demonstrate how the four levels developed over time. This additional layer is important for answering the final research question concerning the development of the preservice teachers' personal PCK and topic specific professional knowledge.

### **What Participants Notice**

To discuss the development of participants' ability to notice, I draw primarily on their individual written reflections for lessons 1-4. All preservice teachers posted a written reflection based on their individual viewing the video of the lesson their group taught for lessons 1-4. My reflections as a moderator/researcher are used to uncover and bracket my biases, as well as detail my insights. The discussion is organized into two main parts, initially and near the end, to illustrate the progression of their skills. The section entitled "What participants notice initially" covers patterns in the data following the first two lessons, so it includes individual reflections 1 and 2, PLC 1 and 2, and the relevant researcher journal entries. The second part, "What participants notice near the



end,” details findings from the same data sources but following the teaching of lessons 3 and 4. Although all data related to lessons 1-4 were reviewed to determine overarching patterns, I illustrate the shifts in the preservice teachers’ abilities to notice through selections primarily from individual reflections 1 and 4.

### **What Participants Notice Initially**

In the beginning, 16 out of 18 participants exhibited an ability to notice students’ thinking consistent with van Es’ Level 1, as was apparent in their assessment and discussion of student learning based on overall impressions of how the lesson went, instead of on specific evidence from student/teacher interactions. These participants also demonstrated another baseline attribute, a primary focus on what the teacher does rather than what the students understand. A few participants (2 of the 18) however, were able to grasp the concepts of noticing more readily and thus exhibited attributes of Level 2, even initially, evidenced in their discussion of specific interactions illustrating individual students’ thinking.

**Level 1: Focus on learning as a whole class and teacher’s pedagogy.** The following excerpt, taken from a reflection posted by a member of the second grade teaching group, discusses the explain or conclusion portion of their lesson on force and motion, but it looks at the event generally, providing a description of what occurred rather than what students understood, without focusing on any individual student’s ideas. This general focus on learning reflects 16 out of 18 of the participants’ initial comments.

Ms. Holiday was asking students in a large group discussion about what force is and how it affects objects. The students raised their hands and shared what they got from the stations (individual reflection 1).

This participant selected a portion of the video that highlighted student thinking, but instead of students' individual responses, she focused on how the teacher set up the situation (pedagogy) and how the class responded as a whole. This level of attention does not provide enough information to assess student understanding.

The following excerpt from another participant in the same second grade teaching group addresses student thinking generally before moving on to describe what the teacher is doing in relation to student responses as a whole group.

For this clip there is a little attention given to student thinking, but there still could have been more. Ms. Waldron asked the students if the car would move as easily if it was an actual car and was huge. The students all answered with no and said that it wouldn't move as easy if it were heavier. Here the teacher could have gone into some more detail about how weight affects the movement of objects (individual reflection 1).

Even though the assignment was to choose a clip focused on student thinking, the statement focuses on the teacher instead and critiques her performance.

**Level 2: Focus on pedagogy and individual student's thinking.** Even initially, however, 2 out of the 18 participants discussed specific student/teacher interactions when reporting incidents of student thinking, demonstrating Level 2 on the van Es framework. For example in the following excerpt, a member of the third grade teaching team describes a specific teacher/student interaction, discussing both the teacher's intention and a student's thinking even suggesting additional probing questions.

The question that students were asked in this instance, "Why would I show you this video?" relates to the learning objective that students will explore sources of light and how it travel The purpose of the question was to get students thinking about how the video relates to light and what happens when things are blocking the sources of light. One student replied that the video had light involved and that the class was learning about light. At this point the teacher could have probed student thinking further by asking a clarifying question. The student response of "the video involved light and we are learning about light is a vague response. The teacher could have asked, "What about the video reminds you of light? How do you know the video involves light? What aspects of light does the video portray?"

These types of questions could have helped direct the thinking of the students and the class (individual reflection 1).

This move to attending to specific students' thinking and ways to further pursue it is a first step towards a more analytical approach to teaching. While 16 out of 18 participants described the clips they picked in general terms, relating what an interaction was about and how it proceeded or what the teacher did or did not do, a few (two) quickly grasped the concept of noticing, examining specific interactions and even provided possible probing questions.

### **What Participants Notice Near the End**

While 9 out of 18 participants were just beginning to display Level 2 ability to notice by end of the fourth week, two had progressed to Level 3 and seven had progressed as far as Level 4. Those at level 2 were still focused on what the teacher was doing and just beginning to attend to individual students' thinking, whereas others had progressed to making connections between what students were thinking and suggesting effective teaching strategies based on that thinking.

**Level 2: Attending to particular students' scientific thinking.** The following excerpt by a member of one of the third grade groups, while it focuses primarily on teacher pedagogy and does not describe an interaction per se, illustrates a beginning focus on student thinking in that after describing the context and the teacher's questioning, the participant describes how the teacher probed students' responses. This places the participant at the beginning stages of Level 2, which, although not unique to this participant, depicts a minor subset of the full case.

Here (referring a particular section of the video of the lesson) Rachel had the students form a circle for a discussion about what they just observed and learned during their investigation. She asked students which light sources they used, and what happened with each object. After each student gave an answer, she asked

probing questions so students could dig deeper into their own thinking and reasoning (individual reflection 4).

This example of attention to the teacher's probing of students' thinking to guide their understanding shows development not only of the participant writing the reflection but also of the participant who was teaching. Becoming more adept in probing student thinking made noticing more productive by providing richer information to analyze and use to make instructional decisions.

**Level 3: Focusing on what specific students think.** The following excerpt from an individual reflection on lesson 4 exemplifies a focus on a specific student's thinking about what was happening to make a straw look bent when placed in water.

In this clip a student is trying to give a definition of refraction in their own words. The student ends up describing how the air pushes the straw one way and the water pushes it the other causing it to bend. The teacher could've probed this student's thinking to see if he really thinks the air and water bends the straw or if it just looks that way (individual reflection 4).

The specificity of the description depicts a higher level of noticing skill. Additionally, the participant realized that this was a critical incident as it exposed a possible misconception of the main learning objective and communicated this realization by observing that the teacher could have probed the students' thinking more deeply.

**Level 4: Connecting teaching strategies to student thinking.** The following excerpts from individual reflections on lesson 4 demonstrate that participants were starting to connect teaching strategies with student thinking and at least partially fulfilling attributes of Level 4. Four of the participants from the second grade group and three from one of the third grade groups had progressed to this level by the end.

The first example is from the second grade teaching group, whose lesson was about force and motion. All members of this group progressed from thinking about

student learning in general terms (Level 1) to observing how the teacher interacted with the students helping them justify their claims using evidence. So as preservice teachers are helping their students to learn to justify their claims with evidence, they themselves are learning to base their claims (curricular decisions) on evidence (Level 4). In the second example, a participant from a third grade group reflects on a specific juncture in the lesson where she as the teacher could have used questioning to scaffold the students' conceptual understanding of light absorption. The participant also identifies this as a critical incident where she could have provided a bridge between the exploration phase and the more formal concept presentation of the explain phase.

Participant 1: I think Holly did a really excellent job of facilitating student thinking instead of simply giving them their answers. I think this is really essential to getting students to develop their own ideas/claims and teaching them to reason through how they arrived at that claim. I think the only thing Holly could've done differently was she could have recorded the responses the students were giving so that everybody could see it on the doc camera. I think students like seeing a record of their thinking and it can be a record of evidence for their overall claim (individual reflection 4).

Participant 2: I could've asked students what they thought was happening when the light did not pass through. This may have lead the students to the idea of absorption. I also could have clarified that the light was not bouncing, or reflecting off of these surfaces. This would have been a good segue into the wrap up that I did not get to (individual reflection 4).

Both of these examples signify a realization of how to expose and push student thinking, a critical component of noticing. Such understanding of how teaching strategies can be used to scaffold student thinking can enable them to construct and implement a responsive curriculum based on what they notice about the students' understanding.

To summarize, *what* the majority (16 out of 18) of preservice teachers noticed initially about student thinking was what the class as a whole understood rather than individual students' thinking. These participants were also focused on what the teacher

what doing rather than what the students understood indicating a Level 1 on van Es' 2011 Framework for Learning to Notice. Two participants however, were already attending to specific students' thinking demonstrating a Level 2 for noticing. By the end all participants were focusing their attention more on specific students' thinking (Level 2) and half of the case had progressed even farther, two to Level 3 and seven to Level 4. The participants reaching Level 4 were demonstrating not only attention to specific student's thinking, but were connecting teaching strategies to that thinking. See Table 3 for a breakdown of levels of noticing attained by each teaching group.

### **How Participants Notice**

The second component of van Es' (2011) framework for noticing concerns "how teachers analyze what they notice, including both their analytic stances and levels of depth" (p.138). Analytic stance refers to how teachers approach analyzing classroom interactions as well as their own teaching and learning, and whether teachers are evaluating or interpreting students' ideas. The level of depth refers to the amount of elaboration and evidential support their interpretations entail. This section reports how teachers' analysis of what they noticed progressed over the course of the five-week intervention. To investigate the ways in which the preservice teachers demonstrated their ability to notice, I again drew on their individual reflections 1-4. I also consulted the entries from my researcher notebook to both realize and bracket how my personal orientations may have biased the findings. I organized the findings into two main parts. The first, 'How teachers notice initially', covers patterns in the data following the teaching of the first two lessons, including individual reflections 1 and 2, PLCs 1 and 2, and the researcher's journal entries after these lessons. The second part, 'By the end', details findings from the same data sources but following the teaching of lessons 3 and 4.

Although all data related to lessons 1-4 were reviewed for overarching patterns, I illustrate how the preservice teachers developed skills for noticing by comparing selections of various participants' individual reflections 1 (initial) and 4 (by the end) in order to paint a clear picture of the shift in their ability to notice.

### **How Participants Notice Initially**

Initially 10 out of 18 participants provided only general impressions of what occurred and/or evaluative comments, placing them as Level 1. Some (8 out of 18) however were more advanced even initially as evidenced in descriptions of specific events and interpretive comments in their individual reflections.

**Level 1: General impression of what occurred.** This reflection by a participant from the fifth grade teaching group provides only a general overview of the situation, focusing on context rather than on a student's thinking, illustrating level 1 of how teachers notice.

During this time, the students are preparing to watch a demonstration over finding volume through water displacement. The students are asked to make a prediction based upon finding out that one jar is heavier than the other. As the students share their predictions, they are further questioned (individual reflection 1).

Because it does not hone in on specific interactions, this way of noticing does not provide sufficient evidence for analysis.

**Level 1: Evaluative comments.** In the following statement, another participant in the same fifth grade teaching group discusses a student's response from an evaluative perspective rather than describing what the student said and then interpreting what that might mean about the student's level of understanding.

The student who replies in the main section of the clip makes a very good statement about the volume doesn't change because the jars are the same size and the weight doesn't matter (individual reflection 1).

The focus on the correctness of answers fails to promote understanding of what led the student to respond that way or portray what the student understands about what volume is or why it is not dependent on weight.

**Level 2: Noteworthy events as evidence.** Eight of the eighteen participants, on the other hand, started at Level 2 noticing, attending to noteworthy events in the lesson and using them as evidence for ways to bring out student thinking.

I think to probe students' thinking even further, Kathryn could have asked students to expand on some of the examples they noted from the video clip. Instead of saying "ok that's good" she can say things like "OK and how does the difference in the sizes of the golf ball and the blowing ball effect how they move?" And when students such as Larry try to get off topic or be silly by bringing up the "fat guys bumping into each other" in the video, she could have probed his thinking by saying "What does that have to do with their motion?" Then she could talk about their weights clashing being a force that is a factor contributing to the movement or lack of it (individual reflection 1).

The participant's discussion focus on specific events and what they mean about student learning places them at Level 2 noticing.

**Level 2: Interpretive comments.** In this example, a participant from a third grade teaching group both notices and interprets the effect the teacher's probing had on student learning.

The teacher is asking, "What is something that we can see through that maybe we shouldn't be able to?" A student says water. The teacher gets excited about this answer and probes the class on their thinking about why we can see through water and what kinds of things we could do to the water so we couldn't see through it. This is a great example of giving attention to student thinking because the teacher is asking the students to apply what they know about seeing through water rather than just asking why you can see through water (individual reflection 1).

The participant's discussion of specific events as evidence to be used in interpreting the interaction designates this as a Level 2 response.



## **How Participants Notice Near the End**

By the end four participants were just beginning to acquire the attributes of Level 2, namely highlighting noteworthy events and beginning to attend to specific interactions. The majority (14 out of 18) however, had progressed to a Level 4 stage of how they noticed, which mainly manifested with participants making connections between events and principles of learning and teaching, as well as proposing valid alternative pedagogical strategies.

**Level 2: Highlighting noteworthy events.** The following excerpt from a fifth grade teaching group member's reflection on another group's teaching of a lesson exemplifies highlighting noteworthy events and noticing a critical incident in the lesson, that is, a point at which students' thinking is exposed and can be used to guide their understanding of the concepts of force and motion. This demonstrates a Level 2 on the framework for how teachers notice.

This is a wrap up portion of the lesson where the teacher is guiding and probing the students' thinking further about what they experience with the different materials on the slide (individual reflections 4).

Recognizing critical incidents (Seidel, Stürmer, Blomberg, Kobar, & Schwindt, 2011) is a crucial step in noticing, without which important aspects of student understanding are missed.

**Level 2: Focus on specific events/interactions.** The following excerpt from the individual reflection of another second grade teaching group member reveals the participant's focus on three specific teacher-student interactions, placing her response at Level 2 as well:

Hope did a really good job of probing student thinking in this clip. She didn't let the student just stop at "I don't know" and encouraged him to really think about

what was happening when he went down (the slide). She ended up getting a pretty good answer out of the student. The next student she asked more questions to understand what the student thought influenced what happened when she went down. She then asked for clarification when she was unsure of what the student was saying (individual reflections 4).

This example also shows how different interactions serve different purposes. The reflection detailed the teacher's probing to uncover, clarify, and push student thinking. All of these ways of focusing on specific interactions serve to provide the teacher with information to analyze and then decide how to respond instructionally.

**Level 4: Making connections between events and principles of learning and teaching.** Quite a few (14 out of 18) participants progressed all the way to Level 4, showing they were making connections between events and principles of teaching and learning. The following response by a member of the second grade teaching group suggests that having students make predictions before rather than during the explore phase would have yielded more thoughtful predictions that could then be compared with their exploratory observations.

I think a big way to change the lesson to more fully address the students' needs is by making the students form their predictions before going outside. This would allow the students to really put thought into their predictions. This would also allow the students to be able to think more about why their prediction was correct or incorrect (individual reflections 4).

The participant points out the connections between what transpired and principles of learning and teaching, discussing how the students might have constructed more thoughtful predictions in a quiet environment.

**Level 4: Proposing alternative solutions.** In the following excerpt, a fifth grade teaching group member proposes alternative pedagogical solutions based on assessment of student understanding. This example illustrates an alternative progression of ideas to help students build understanding:

I think that something that could have helped with the confusion and probed the students' thinking a little bit further would be if we discussed mass first and then weight. If we established that mass is how much of an object there is, it would be easier to explain weight as the pull of gravity times that mass, Perhaps with further probing and different questioning techniques, Gordon could have pulled more insight from the students on this particular concept (individual reflections 3).

This alternative pedagogical strategy involves restructuring the sequence of how concepts were presented. The participant suggested that presenting mass first could have helped the students build a more cohesive understanding of volume and weight. Proposing such alternate solutions indicates knowledge of both the importance of concept progression and the need to vary pedagogical solutions.

To summarize, initially the just over half of participants were noticing in a general, evaluative way (Level 1) and a bit less than half were already focusing on and interpreting specific interactions (Level 2). By the end, however only four participants were still at a Level 2 for how they noticed, indicated by their attention to highlighting noteworthy and specific events. The majority (14 out of 18) however, had progressed to Level 4, indicated by their ability to make connections between events and principles of teaching and learning and to propose valid alternative pedagogical strategies. See Table 3 for a breakdown of levels of noticing by teaching group.

### **Aspects of Scaffolds Attributed to Changes**

This section focuses on the findings for the second part of research question one, aspects of the intervention to which the preservice teachers attributed their progression in noticing skills. The findings suggest all three scaffolds (video-analysis, moderator scaffolding, collaborative reflection) worked together to support changes in participants' beliefs and abilities to notice students' thinking about science. While each component is

Table 3  
*Group Grade Level, Topic and Sequence of Lessons & Progression of Levels of Noticing*

Group # Grade	Topic by Lesson	Initial Level of Noticing	Level of Noticing Near the End
1. Grade 5 Conservation of Matter, Mass/Volume Relationships	1) Differences between weight and volume 2) Measuring weight and volume 3) Weight Volume and Mass 4) Conservation of Mass in relation to weight and volume 5) Conservation of Matter – Changes in State	What –Level 1  How- Level 1	What –Level 2or 3*  How- Level2*or 4
2. Grade 2 Motion	1) Introduction - How objects move 2) Forces – Pushes and Pulls 3) Why do objects stop moving? 4) Friction 5) Gravity	What – Level 1  How- Level 1or 2	What –Level 1or 4  How- Level 2or 4
3. Grade 3 Light	1) What is Light? 2) How light travels through different mediums - shadows 3) Light spectrum/wavelengths 4) Refraction 5) Reflection	What – Level 1or 2*  How – Level 1*or 2	What – 2*,3*, or 4  How- Level 4
4. Grade 3 Light	1) How Light Travels 2) Refraction 3) Reflection 4) Shadows 5) Light Sources	What – Level 1  How- Level 1	What – Level 2  How – Level 2*or 4

\* Only 1 participant in the group was at this level.

first discussed separately below, it is evident that the cumulative contributions from each scaffold affected the amount of growth. For instance, the quality of the interactions within the teaching group PLCs had bearing on the members’ abilities to use the video of their teaching in learning to notice. Of the four teaching groups, one worked extremely

well together. This was one of the third grade teaching groups. All members consistently thought about and contributed improvements and suggestions for probing student thinking and modifying both previous and future lessons. This group always stayed on task with all members focusing on improving their unit even if they were not the lead teacher that week. This group also advanced more rapidly in their noticing skills than the other groups. In contrast, the other third grade teaching group was off task frequently and didn't take the time to learn about each other's lessons from week to week, thus struggling with developing their ability to notice children's thinking when working in class. They resisted watching and discussing the clips of their teaching, and when they did, they exchanged only positive comments the majority of the time. One of the members even responded that she did not know enough about one of the other member's topic to help in offering alternative probes even though all members were to have knowledge about the entire unit. The other two groups, the second grade teaching group and the fifth grade teaching group fell somewhere in the middle of this continuum. In the following section, I first report on how participants perceived the benefits of each of the scaffolds, followed by a discussion of the benefits of the three scaffolds combined. To illustrate the findings, excerpts are provided from transcripts of the post interviews, exit slips 1 and 4, and the final survey given during their lesson study after their last lesson.

### **Video**

The participants attributed learning to notice critical incidents to individually reflecting on their videos, which allowed them to assess their teaching free from the distractions of the classroom and emotional impact of teaching.

The individual reflection allowed for us to do our own thinking without getting overwhelmed with all the other group members (exit slip 1)

The individual reflection really helped me to go back and really reflect on what went good and what might need tweaking, When you're actually in the classroom it's hard to evaluate how things are going because you're so focused on the students and the lessons (exit slip 1).

I thought it was very useful to watch the videos and reflect on things we didn't notice as we were teaching (final survey).

As these comments acknowledge, with the many competing aspects that vie for a teacher's attention in the classroom, learning to notice necessitates a selective focus on student thinking. Video therefore proves to be a valuable tool for developing a reflective stance.

Because of the emotional component involved in teaching, the participants benefitted from having video to reflect on the lesson separated from the teaching environment, as expressed in the next excerpt.

It was super effective to have us reflect on the video because after a lesson we reflect, but are so influenced by emotion it's hard to actually sit down and objectively analyze it (exit slip 1).

This participant realizes the objectivity that video provides, a feeling that is representative of the case as a whole.

Watching their videos along with the support of the community helped the participants focus on evaluating specific parts of the lesson, which helped them analyze their teaching effectiveness as well as in guiding their modification of the next lesson. They attributed their ability to recognize critical incidents and prompt students to take their thinking to the next level to watching videos of their own practice both individually and with their PLC.

Watching the videos really showed me that I need to really listen to students' responses and ask deep probing questions (exit slip 4).

It helped doing the individual reflections and then discussions in a group because we could talk over ideas (exit slip 4).

Because the participants designed and taught their lessons with their group and participated in video-assisted reflection on practice with their PLC, they held a wider perspective on the classroom interactions.

## **PLC**

Participants asserted that the PLC helped them learn to analyze critical incidents and decide next steps. The exchange of ideas within the PLC also helped them benefit from multiple perspectives.

The Community helped modify the next lesson and how to analyze your teaching (exit slip1).

The most useful (part of the intervention) was reflecting on the lessons with the other preservice teachers after we taught. I really liked the opportunity to go back and reflect on the lessons that is something that we have never had the opportunity to do before (final survey).

This experience of non-evaluative feedback from the group was a new experience for many of the participants.

So having each other to bounce ideas off and plan things like, well what do you think about if I did this rather than this? Do you think that would work? That was really beneficial (interview post).

As these excerpts exemplify, participants felt the PLC assisted them in deciding how to progress based on what they had discovered about student thinking. This last stage of noticing is dependent on the first two steps, noticing and then analyzing critical incidents.

## **Subject Specific Moderator**

Participants noted that I, as the moderator, helped guide groups in learning to make changes that would expose student thinking. They also felt that I helped participants to confront inconsistencies in their thinking such as that frontloading was inconsistent with a learning cycle format. Additionally, they saw me as the driving force in the realization that letting students handle materials is a necessary component of

inquiry learning (moderator journal). In the following excerpt from one participant's post interview about the three aspects of the intervention, the participant first cites watching the video with the group as helpful and then comments especially on my contribution as the moderator:

Sometimes our group would talk about it and still not be able to think of any conclusions but it was good to see that we could recognize where the problems were...then the talk with you was super helpful cause sometimes I know Toni especially, and then once I got to my lesson, we were very unsure if what we were doing was correct, but then talking to you was very reassuring and you helped us make connections especially in between our lesson, like the glass that we shined it through, that was really, really helpful for the kids and helped draw our lesson back together, And then you helped to explain like how to not frontload because we understood the idea of not wanting to explain to the students, wanted them to get it themselves but at the same time we were like, they're not going to get it themselves so it was really effective if we don't know how to guide them and so talking with you about how to solve those problems was really helpful because then we got to see how they can explore it and then how by asking them the right questions and giving them the right tool you can get to the lesson that you were trying to explain without just simply say this is what it is and this is why. So obviously talking to you was very, very, helpful (post interview).

Due to their inexperience with teaching science, the participants were often unsure how to present material to their students and prompt their learning, and in the role as subject specific moderator participants noted that I gave them useful guidance in their planning. In addition I helped them to see how they could specifically enact theory in their practice, especially by applying a learning cycle format, with which many had little personal experience.

Overall, the participants asserted that the moderator, acting as a coach inspired and reassured their teaching.

You (the moderator) were very helpful in guiding, assisting and giving us more confidence in teaching (exit slip 1)!

This reassurance was valuable in soothing the insecurities of these novice teachers.



Additionally, as the following excerpts illustrate, I as the content specific moderator also helped explain the subject matter and gave tips on how to present information to students.

The moderator helped make the lesson the best it can be. She gave us advice how to teach science in an elementary school (exit slip 4).

Moderator help us learn how to research our topic and gather the correct supplies to make your lesson the best it can be (exit slip 1).

Holding the larger picture of effective science teaching, as the moderator I was able to help participants realize and fill in the gaps in their practice by pointing out places they could improve their lessons and giving them practical examples of how to accomplish their goals.

### **Combination of Scaffolds**

Participants attributed many practical benefits to the combination of scaffolds, including how to teach science by stimulating student thinking, how to structure instruction to guide student learning, and how to convey ideas without frontloading the information.

For instance, although the participants' move away from frontloading was attributed to the content specific moderator's encouragement, the dynamics of their teaching group PLCs also contributed to their growth in this area. The group who advanced most in their noticing skills actively elicited help in structuring lessons effectively, whereas other groups that did not elicit help or even blocked the moderator's suggestions, indicating the impact that the teaching group PLC had on the participants' individual progression. Thus, the collaboration with both with their peers and with me, in the role of content specific moderator, was shown to play an essential role in building the preservice teachers' understanding of and abilities to notice students' thinking.

Participants attributed some of their learning, such as how to teach science by stimulating student thinking, not to specific scaffolds but to the intervention as a whole and even acknowledged input from their science methods course and field experience.

The intervention was helpful as it pushed our thinking and challenged us to go further with probing the students' way of thinking. Watching videos of our teaching was so helpful as it allowed us to make revisions for the following week (final survey).

I thought it was very helpful to be able to see ourselves teach, talk about it, analyze it, and then apply it. We were given several extra resources and constructive criticism to make our teaching and teaching techniques better and better each time (final survey).

The scaffolds worked both separately and in conjunction to form a cohesive cumulative grid of support.

The methods course aligned with the intervention by contributing the supportive frameworks of the 5E Learning Cycle format, CER (claims, evidence and reasoning), and the use of focus questions to guide student learning. In the following excerpt, one participant elaborates on her assertion that learning the 5Es was very important to her understanding of how science should be taught:

I think mainly how students arrive upon conclusions for themselves that was something that I knew was important but didn't realize how important it was and we talked about that in our meetings on Wednesdays, how it was important not to not frontload them but to give them and experience that then they can connect, and experience that they have themselves and they can connect that with the scientific kind of knowledge and how important that is and how it's important to let them arrive upon that conclusion no matter how long it can take instead of you just stating it (interview post).

Learning how to enact the theoretical ideas introduced in their methods class was supported by the intervention in conjunction with their field experience.

The following quote details how the intervention gave the participants practical knowledge.

I definitely think what we did for the study helps with the practical side of teaching so all of this information about frontloading. I definitely learned from you and making that kind of mistake in our lesson and fixing that for the following lessons (post interview).

The methods course provided the theory, the intervention provided guidance on how to apply it, and the field experience provided the opportunity to practice it.

To summarize, participants attributed learning to recognize critical incidents, assessing their teaching, and probing student thinking to the video component of the intervention. They credited the PLC with helping them analyze critical incidents and decide next steps, and the subject specific moderator with helping them connect theory with practice and providing content and pedagogical advice. Although the participants specified the contributions of each scaffold, they realized that the combination helped them learn to structure their instruction to provide a responsive curriculum.

### **Modifying Instruction Based on Student Thinking**

Noticing entails recognizing critical incidents, followed by probing and analyzing student thinking to guide instructional decisions. Question 2 focuses on the instructional decisions. To answer this question, I referred to data from the lesson modification portion of the PLC meetings and the whole group sharing portion of PLC 3. I also consulted my researcher journal to bracket my findings.

Initially, participants modified instruction by frontloading information and by focusing on logistics for implementing their prepared plans. They demonstrated frontloading or telling the students the information instead of supporting students to build their own conclusions about the concepts. By telling students what they were to learn or what they had learned. As such frontloading can take place at the beginning of the lesson before the explore phase by telling students what they would discover, but also during

and after the explore phase in telling the student what they learned instead of guiding students to form their own conclusions. By the second PLC they had progressed to discussing subject matter and how to teach. As the moderator I modeled ways to set up learning experiences that would guide participants' students to develop their own understandings.

By the end, while participants understood they should not frontload material, 3 of the 4 groups still reverted to the frontloading tendencies of didactic instruction when confronted with student confusion. However, they all realized that despite wanting to stick with their initial unit trajectory, students should not move on to a new concept without understanding the last. They also realized the importance of structuring learning progressions to allow ideas to build upon each other. Other modifications exhibited were writing out probing questions before hand and incorporating constructivist experiences into their lessons. Additionally participants from one of the third grade groups had progressed to the point that they were even planning experiences to address specific student misconceptions.

### **Initially**

Although their plans called for it, participants were not initially enacting lessons with a learning cycle format. Additionally when confronted with teaching unfamiliar subject matter, they fell back on their own prior science didactic learning experiences. They also demonstrated their belief that eliciting students' prior understanding at the beginning of the lesson and providing hands-on experiences was sufficient for providing a learning cycle experience for students. Also their focus on the details of existing plans kept them from fully understanding and embracing a student-centered way of teaching.

**Frontloading.** Initially, the modification of choice for all groups to address students' failure to comprehend a concept from a previous lesson was to review the content again (by writing out concepts or discussing correct definitions) and then proceeding on to the next topic. As the following excerpt shows, when I as moderator pointed out a lack of evidence that the students understood the concept of volume, the preservice teachers agreed, but the lead teacher's solution was to go back over the definitions given in the last class and then move on to a new concept, mass.

Moderator: Somehow I would like them to get the idea the volume is taking up space because I don't think they have that solidified in their brains.

Participant: They don't have that concept.

Moderator: Tell me how you plan to introduce your lesson.

Participant: Change the lesson plan to bring in the posters that we had last week, since we only meet with them once a week. We'll start with reviewing what they've already done. When they come back in we'll have the posters taped up and we'll review the concepts. Then we'll have them go to their stations and the last station has them do mass (lesson modification PLC 1).

I encouraged the group to have the students give their own definitions of volume and weight to uncover possible misconceptions instead of simply restating the information again. I also advised against going on to a new concept while the students were still confused about the first two. While they grudgingly followed my advice about not moving on to mass, they held to their remediation plan of reviewing the definitions as the appropriate method for addressing the students' confusion. Additionally they designed the next lesson to focus on measurement of weight and volume instead of focusing on understanding each concept separately first. The only reference to what each concept meant was made when the lead teacher asked them what they had learned by measuring volume at her station. When she got no response, she moved right into closed questions, "What didn't we use to measure volume?" Then she went on to ask, "What's our word

that goes with volume?” Finally she took through a chorus of repeating, “When I say volume, you say space.” Such frontloading of information and reverting to didactic strategies represented how the majority of participants initially made lesson modifications.

**Attachment to existing plans.** Whether they were unsure of how to remedy students’ confusion about concepts or they simply resisted the effort of modifying their plans, initially 3 of the 4 groups did not want to change their original lessons or consider modifying their next lesson, so some groups spent the entire lesson modification time talking about the logistics of their preexisting lesson. For instance, even though the second grade group realized that their frontloading of the concept that force was a push or a pull in their last lesson had created an issue, they did not however consider whether it would be an issue in their next lesson. The issue with their lesson was related to the way students were using vocabulary, which clearly showed that they themselves did not conceptually understand the words’ meanings. For instance the fifth grade group was so fixated on the lesson they created that they spent the time allocated to reflecting on student thinking demonstrated in the previous lesson to going over the details of the lesson instead, ignoring the information they were supposed to be using to modify their next lesson.

**Discussing pedagogy and subject matter.** By the second PLC, 3 of the 4 groups were approaching modification by discussing ways to structure the lesson to most effectively introduce the concepts to the students. For instance, one group discussed how a video could help students understand the target concepts.

Participant 1: Are we doing the video still or no? What video? We had a video on our thing?

Participant 2: Does it explain what mass is on it? Because we are trying to have them come up with it

Participant 1: We don't want to show a video that tells them.

Participant 2: We can show it at some point. Yeah, maybe at the end. How long is the video?

Participant 1: Well the one I'm looking at is five minutes... so not too bad.

(They then review the video and come to the consensus that they do not want to include it.)

Participant 1: So we don't want to show those videos?

Participant 2: No that's all frontloading right there (lesson modification PLC 2).

They then planned to first review followed by asking some of the critical thinking questions I had sent them along with resources to bolster their weak subject matter knowledge. They discussed how to use the questions to engage the students, which also helped solidify their own understandings of the concepts. This conversation represented an advance in many ways. First, the group was thinking and talking about the subject matter and how to get students to understand it; and secondly they had internalized what constitutes frontloading and reasons not to use it. The lead teacher also discussed how to connect the questions to the lesson objective, and one of the group members added, "They don't have to give the right answers. We can just see what they know" (lesson modification PLC 2), demonstrating a move away from seeing themselves as disseminator of information to facilitator of student learning.

### **By the End**

This section covers the second half of the intervention, for which I examined the 3<sup>rd</sup> and 4<sup>th</sup> PLCs for evidence. There was no fifth PLC because the fifth lesson was taught the last week of classes and the PLC could not be held during exam week.

After the second PLC, I eliminated the whole group video viewing portion due to participant feedback and my determination of its ineffectiveness as a scaffold for noticing

techniques. The four key findings to address how participants made modifications to the lesson plans are described below.

**Deeper understanding of probing.** Many groups found that they were not probing deeply enough to assess students' understanding. They became aware of this problem while reviewing videos of their lessons and were able to project that the issue would arise in future lessons. Their solution was to write out a list of potential probing questions beforehand as the following excerpts illustrate.

Participant 1: so we make sure that we're getting to the deep... Instead of just saying, oh why? Thinking of questions that get at the deeper meaning will help their thinking as well. It is hard to think of them [these types of probing questions] on the spot (lesson modification PLC 3).

Participant 2: probing is always an issue with us. We probe but never enough. I think we need to take it one step further. We don't know how to do it in the moment. We never know how (lesson modification PLC 3).

As the intervention progressed, participants raised their standards for probing questions, and they were able to use this strategy to elicit and assess a more detailed picture of student understanding before deciding how to act on it. Even as participants were becoming better at probing, they still reverted back to didactic pedagogy when addressing students' preconception and misconceptions.

**Confronting misconceptions with didactic pedagogy.** Although the participants were aware that they should not be frontloading, when their students did not comprehend a concept they fell back on didactic instruction. This was demonstrated by both, the second grade teaching group and the fifth grade teaching group. The fifth grade group in considering how to modify their fourth lesson to address students' continued confusion about volume, weight, and mass responded by reviewing. Rather than design another experience to help the students clarify these concepts, they chose 'telling' the students as



the most effective means for getting the students to understand. This is illustrated by the following comment from one of the fifth grade team members during group planning, “We could even have it be a ‘let’s clear up misconceptions and review’” (lesson modification PLC 3).

The second grade group employed the same tactic when discussing their lesson, where students were using words for concepts without really understanding them. Their modification to address this issue was to provide definitions of all the terms the students had learned, leaving out the new concept, gravity so students would not get confused. This tendency to revert back to teacher-centered instruction shows that the participants were still attached to the didactic pedagogy they were familiar with, but which prevented them from modifying their instruction in a way that would help them uncover student thinking as well as improve their noticing skills.

**Ideas build on one another.** By the end of the intervention all participants became aware that that ideas need to build on each other was manifested in two realizations: 1) they should not move on until students have grasped the lesson objectives, and 2) lesson sequencing within a unit affected learning. Even though the fifth grade group struggled with implementing a true learning cycle lesson format, they knew that because the students were not clear on the concepts of mass, volume, and weight, they were not ready to move on to the next concept of conservation of mass.

Participant 1: We don’t want to move on our original lesson is about conservation of mass and stuff. They don’t understand that yet, so we don’t want to jump into the conservation of it. I think it would be more beneficial for them and for us some clearing up of misconception and then kind of a skit thing at the end. To let kids guess what they’re talking about (lesson modification PLC 3).

When the moderator asked whether they would still cover conservation of matter next time or just not get to it, they responded,

Participant 1: Just not get to it.

Participant 2: There's no sense in moving on if they just don't get it.

Participant 3: We can't really build off the idea of that.

Participant 2: Yea conservation of mass, they have to have an idea of what mass is or they are not going to get it (lesson modification PLC 3).

This realization is key to a responsive curriculum. The decision is based on noticing and assessing the student level of understanding.

By the end of the intervention, all groups also understood the importance of structuring lesson progressions. As they taught their units, they realized that part of the students' confusion may have stemmed from the order in which they presented the ideas. One of the groups decided that the students would have understood weight, mass, and volume better if they had begun their unit with mass, which in retrospect they considered to be fundamental to understanding weight and volume. Because the students had not cemented these concepts, when mass was added, it really confused them.

When we were doing definitions of weight and mass, if we had done mass first we could have helped them realize mass is what something is and weight is what that is being pulled down by gravity (group sharing PLC 3).

Another group thought changing the progression of their lessons by adding a lesson on energy in the beginning would help students make connections among all the light ideas more readily. The lead teacher was discussing how she had the students make white light by shining all the colors of light onto one spot. She then wanted to connect the idea that light is energy to which each color contributes a bit. The students struggled with this concept, spurring the group to consider initiating the unit with a lesson on light as a form of energy.

The kids know from previous years that light is energy. They can tell us that in their FAI but I'm not sure they know exactly what energy is. I was trying to make the connection that each color we pointed has a slightly different energy and that's where they got lost. They understand that all the colors make up white light now but I don't know if they really get the whole energy thing so we talked about filling in a lesson at the very beginning that was totally focused on light is energy (group sharing PLC 3).

This example shows how noticing leads to awareness of students' thinking and consideration of possible changes for a responsive curriculum.

**Starting to design constructivist learning situations.** The groups were also beginning to realize how to set up learning experiences that allow students to form their own understandings. For instance, the second grade group designed a very innovative lesson on friction in which they had students slide down slides using mats made of different materials. However, although the group set up the explore phase expertly, the explain phase failed, due to the teacher's weak subject matter knowledge. This example shows that teacher's knowledge is crucial in tying exploration experiences to formal scientific concepts.

This same group when told their last lesson needed to be an application of concepts learned in previous lessons responded as a unit. They let go of their attachment to the previously developed plan covering gravity and worked together to construct a lesson that had students applying concepts from lessons 1-4.

Participant 1: We really do need to go over friction because that did not go as well.

Moderator: Think about this how to set up an activity that they [the students] have to say which way is the force moving it and which way is gravity moving it.

Maybe make little arrows or something.

Participant 1: Why don't we do tug of war as one of the things, we could bring in arrows and opposing forces.

Participant 2: What if we cut out big arrows and we did different scenarios and like one person would be the force and one person could be the opposing force?

Participant 3: Different sizes. Different colors.

Participant 1: Should this be like everybody sitting on the carpet?

Participant 2: two people come up in table groups and each one of them has a representative

Participant 1: We could be acting it out. They could be like, "That's friction."

Participant 3: Let's write the scenarios.

The group worked well together, bouncing ideas off of each other and getting excited about how to structure the learning experience. Two of the other groups, the fifth grade group and especially one of the third grade groups, did not work as cohesively or effectively and required pushing from the moderator. For instance, the fifth grade group knew that students were still confused about the three concepts they taught, but had to be encouraged by the moderator to give students experiences that would help them build understanding. The third grade group who had struggled with developing noticing skills had to be pushed to change their final lesson into an application of concepts already learned. The lead teacher was fixated on her original idea plan to cover light sources and so tried to implement a review discussion on light as energy to tie all the ideas previously learned together. As the moderator I asked her to institute a learning cycle approach to the lesson that would allow students to explore and then explain their understanding of the concepts, pointing out that if she wanted to bring in the idea of light as energy, students would need an opportunity first to explore the different ways light behaves before (e.g., reflection, refraction and shadows) before describing why this was happening. She resisted having the students revisit all the concepts, arguing that it would be too disjointed. Her group tried to help her think through possible scenarios, but she rejected their attempts, saying she would research and prepare the lesson herself that evening. Finally, at the very end she was swayed to let the group help and the resulting lesson did allow students to interact with all the different ways light behaves as a form of

energy as it comes into contact with different forms of matter (i.e., it reflects, refracts, or absorbs).

Designing constructivist learning situations represented the most advanced responses to student thinking. Not all participants reached this level but the other third grade group demonstrated this skill several times. They were even able to anticipate and plan for potential misconceptions. For example, the group anticipated that their students would think that light appeared white not because of the combination of all colors but because it was shining on white paper, a misconception they dispelled by shining all the colors onto a black sheet of paper as well.

This group also demonstrated their commitment to designing and redesigning experiences to help students confront their misconceptions. They first became aware of a student misconception about what happens to light energy as it interacts with substances when a student with whom they were conducting a formative assessment interview as part of their field assignment thought the water would “eat the energy of the light”. The group thought of using a submersible craft light to dispel this idea, but when the teacher asked the students what they thought would happen when she placed the light in the water, they said it would shine through because the water was transparent, showing they no longer harbored the misconception. The group took this new information about their students’ thinking and created a new demonstration using a heat lamp to “show [that] the object it shines on uses the heat and what is behind it is still really cool so they can see the heat and the energy is absorbed by something, and in the shadows it is not hot” (group sharing PLC 3). These examples show an advanced level of noticing encompassing all

three areas, recognizing critical incidences, probing and analyzing thinking, and then deciding how to respond.

To summarize, as the participants became more adept at noticing, they moved from frontloading information and sticking to preexisting plans to discussing both content and pedagogical strategies that would be useful in the teaching the lesson objectives. Yet even as they were becoming better at probing students' ideas, 3 of the 4 groups were still reverting to didactic pedagogy in responding to student misconceptions. By the end however all participants realized the importance of setting up ideas to build upon each other and were beginning to learn how to design constructivist learning situations.

### **Aspects of Scaffolding to Which Changes Were Attributed**

To address the second part of question two, I examined the post demographic surveys and lesson design tasks as well as the post interviews. I also drew from exit slip 1. Before discussing the participants' perceptions of how the combination of scaffolds helped them learn to use student thinking to modify curriculum, I discuss this for each scaffold separately, including the participants belief in how video-assisted reflection helped them assess student learning and notice critical incidents; how the PLC helped them identify what students did not understand, as well as problems in their practice and possible solutions; and how the moderator supported them by providing reassurance and specific ideas for teaching subject matter.

### **Video**

The case asserted that the video of their own teaching provided a focused environment for reflection allowing the teachers to assess student learning without the

distractions of the classroom. Additionally, due to its iterative capabilities, it also helped them notice more things that could be fixed.

As the excerpts below illustrate, all participants attributed improved assessment skills to watching the videos of their own and their peers' lessons, which allowed them to discern issues with student understanding that were not apparent while they were teaching.

Watching the prior videos and watching my video after I did it [taught] ... sometimes you think you did something and the kids responded. You seem to think it went well but when you watch it you realize they really didn't get what you thought they got. For instance I saw they (the students) would say reflection but didn't really know what it meant (post interview).

Learning to notice critical incidents such as using vocabulary without understanding is an integral part of assessing student learning in order to make decisions about how to modify curriculum.

As the next participant alludes, it was hard for the preservice teachers to evaluate the level of student learning while immersed in the classroom environment with so many issues vying for a teacher's attention that noticing student thinking often takes back stage.

When you're actually in the classroom it's hard to evaluate how things are going [with individuals] because you're also focused on [all] the students and the lesson (exit slip 1).

Due to the distracting nature of the environment paired with the fast pace of student/teacher interactions, videos provide an invaluable tool since they can be stopped and replayed numerous times.

As the following excerpt shows, this attribute allowed teachers to watch interactions more than once to ensure understanding and notice more things about their teaching or their lesson that needed to be fixed.

I really liked watching the videos because you see the lesson in a different lens. In the middle of it, it might seem like it's going really well, when it's going terribly, but then when you watch it you realize it more of one than the other, it could be either way. So I think that was really helpful and you can pause and rewind and re-listen to a statement. Sometimes a kid says something and you kind of think you know what they're talking about but you're not for sure and so at the time you thought of one question but should have figured out more so when you watch it again you can think about other questions and think about if those questions would be beneficial in the future as well. Because sometimes if you think of what you could ask them and it will probably apply in the future (post interview).

Using a video as a reflective tool can help to inform the approach to not only that particular lesson, but future lessons as well. Honing noticing skills in a quiet and focused environment can prepare the teacher to apply these skills in the noisy chaos of the classroom.

## **PLC**

The participants attributed the supportive nature of the PLC to helping them determine what the students' did not understand and assisted them in identifying and solving problems with their practice. The positive experiences they have in these collaborative groups may encourage teachers to seek out this kind of support in the future by joining communities of practice and professional learning communities.

As the participants were learning to notice and assess student learning, the PLC provided a venue in which to share ideas and perspectives and help each other interpret how what students said indicated what they understood about the lesson objectives.

We'd look at what students had written about and we'd say okay they don't get this, we need to go back and do another little activity so we know they understand or we would say okay they got this, we can move on (post demographic survey).

This communal decision making took some of the pressure off the critical tasks of noticing critical incidents, assessing what students knew, and then deciding how to



proceed. The next section covers one of the defining benefits of this type of communities, solving problems in practice.

As discussed in the following excerpt, whether the PLC could suggest solutions to problems was less important than helping participants figure out what the problems were.

I found it more helpful when we talked about it as a group because if sometimes you make a mistake that you don't know how to solve, being able to talk about it as a group is helpful. As we watched the video together we could get everybody's ideas of what they think you did well and what you didn't do well. It was interesting because sometimes people would see something they thought they did well but I hadn't even noticed. And the same thing with bad, you're like, "Oh I completely missed that student's statement there." So it was really good to get everyone's point of view and be able to talk about it and draw conclusions. Sometimes our group would talk about it and still not be able to think of any conclusions, but it was good to see that we could recognize where their [the students'] problems were because you always have people you can go to in your school or you can ask online and try to figure out the solution once you've realized the problem. That's always the hardest part, to see where your issues are (post interview).

The excerpt describes the case's sentiment that the PLC enriched their reflections by providing multiple ideas and perspectives. The input shared in the weekly PLC was particularly useful because all members were familiar with the intricacies of the context and prior learning that had taken place, as well as the characteristics of their particular group of learners. This kind of community fostered acquisition of new pedagogies, which is what the intervention was trying to accomplish. Thus the PLCs helped their members learn to determine what students understood and then to solve problems with these understandings. Even if such a community is not able to generate a solution, it can help to define the problem so that appropriate resources can be sought.

## **Moderator**

The case felt this component of the scaffold directly helped participants learn to create constructivist learning situations by providing them with specific solutions to problems within their practice, such as how to connect unit ideas. They also perceived the moderator as providing reassurance and encouragement as they were learning to teach science. In this role similar to that of an instructional coach, the moderator, being knowledgeable about both content and pedagogy, was able to scaffold and sometimes push participants' learning on an as needed basis.

By the second lesson participants were aware that their students were confused about some of the concepts they were trying to teach, but they did not know how to set up learning experiences that would allow the students to build their own understandings. This issue created most of the problems that the participants had in deciding how to modify their curriculum. For instance the fifth grade group knew their students were not understanding weight and volume but were at a loss as to how to get these ideas across without directly telling them. When I realized they did not have a clear picture of what students actually thought about the concepts, I suggested the group ask the students to write explanations of these concepts in their own words and then assess what they wrote to determine how to proceed. I went on to suggest that they could have a focus question that both served to uncover student understanding and fit with what they wanted the students to do in the lab portion. I detailed what it might look like to have students work through stations designed with this focus. The group was still unsure of how to set up learning in this way, as one asked, "Do we tell them it is weight and it is mass?" I explained they could but should have the students express what the terms mean. Another

member asked, “So then after they did the explore part taking their measurements, we have them write down what do these words mean?” showing that she was separating thinking about the concept from the exploration when in fact this level of engagement should be present throughout. I said I would have students write an explanation of what they think they are measuring on their worksheet at each station and then state what they think the difference was between the mass and the weight stations at the bottom of their worksheet. Even after this clarification, the group was still confused and asked, “Do we tell them what mass is? We tell them they are measuring weight and measuring mass but they [should] have an idea what mass is.” I again explained that their job was to provide the students with an experience showing them the difference between weight and mass. The following quote explicitly expresses what was alluded to previously in the interactions between the preservice teachers and myself as the moderator, the idea that participants required specific examples to make sense of how to enact this type of practice.

Participant 1: In our lesson study (part of their field work assignment) we would talk about how it went and what to do next so then class with you was beneficial in coming up with more specific ideas of what to do (post interview).

Since I not only had a far greater range of topic specific content and pedagogical knowledge but also was familiar with their contexts through weekly review of their teaching videos, so was able to offer specific solutions to issues with their practice.

Participants also saw the moderator role as including the benefits of a counselor, soothing and reassuring them in this new venture. After discussing this aspect of the moderator’s role, the following participant goes on to discuss how coaching helped them connect the ideas in their unit. This is followed by a detailed account of how the

moderator assisted them in designing constructivist based lessons which allowed student thinking to be exposed.

Participant 2: And then the talk with you was super helpful because we were unsure if what we were doing was correct, but then talking to you was very reassuring and you helped us make connections especially in between our lessons. And you helped to explain how not to frontload because we understood the idea of not wanting to explain to the students since we want them to get it themselves, but at the same time we were like, “They’re not going to get it themselves.” So talking with you was really helpful because we got to see how they can explore it and then how by asking them the right questions and giving them the right tools you can get to the lesson you were trying to explain without just simply saying , “This is what it is and why.” So obviously talking to you was very helpful (post interview).

By receiving specific suggestions when they were at a loss for what to do or wanted to respond to student confusion with didactic instruction, the participants were able to uncover student thinking, hone their noticing skills, and experience success with implementing constructivist teaching methods.

### **Combination**

Although participants attributed the development of their abilities to use student thinking to inform their instruction to particular scaffolds, they acknowledged most benefits stemmed from a combination of inputs from the three scaffolds. In this section I discuss how the combination of scaffolds provided a forum for learning to notice, improving noticing skills, and developing a practical understanding of what to consider when revising a lesson. One participant stated of the supports:

It (the PLC meetings) gave the participants a dedicated time to learn this skill in addition to the support provided by the three scaffolds. It was good to have time set aside to modify our lessons, swapping ideas [was] helpful, feedback and opportunity to ask questions from the moderator [was] helpful (exit slip 1).

The scaffolds worked together to help build a full set of skills that could then be applied to building a solid understanding of what to consider when revising a lesson as the following quote alludes to:

I would definitely say the intervention. Just with all the work we've done that we've done with you and the discussions we've had about how children think about science and how to write lessons and reflect on them and revise them and so on (post interview).

This comment highlights the main consideration in revising a lesson, children's thinking.

Finally the three scaffolds together supported development of probing skills, as illustrated in the following discussion of responses from three participants. The first participant mentions input from their methods class, watching and discussing the video with the PLC, and the moderator's input as important in this learning.

Participant 1: I got this from all the practice we had with probing questions from the readings and discussions on asking appropriate questions (methods class) as well as discussion and class with Susan (intervention) where we analyzed our teaching videos and discussed and came up with things we could have asked to probe students thinking even further and take it to the next level (post lesson design task).

Another participant ties learning to notice using the video to applying this skill while teaching.

Participant 2: I think watching the video was really helpful, when you're in the field you kind of just want to get everything done and it's hard to think on the spot of something to ask but then when you re-watch it it's like I should've done this, I should've done that. And so I definitely think our time with you (the moderator) has helped us understand how we can improve our questioning skills and I've seen that just personally and then with my team these five lesson we've gone through that we've improved our probing questions and do not just accept an answer but dig deeper, so it's been helpful (post interview).

Finally a third participant connects the field experience with the intervention and reports that probing served not only to uncover but also to funnel and stimulate student thinking.

Participant 3: I would say I learned about probing thinking from the field experience and from the intervention just like learning about funneling questions and stimulating their thinking through questioning and probing them not only so they understand but also so we understand where their thinking is going (post interview).

As a primary component of the intervention, probing skills provided teachers with much of the information they used to modify the curriculum.

### **Summary**

This question addressed how the participants learned to modify instruction based on awareness of student thinking in relation to the three-pronged scaffolding employed in the intervention. They attributed assessing student understanding and uncovering areas for improving their teaching to the video; assessing students' struggles and identifying and solving problems in their practice to the PLC; and learning to construct learning experiences to the content specific moderator. They attributed learning to notice, learning what to consider when revising a lesson, and learning probing skills to the combined guidance of three scaffolds as well as input from the methods class and the field experience. All the participants expressed the conviction that the three scaffolds in combination helped them learn to modify curriculum based on student thinking.

### **Intervention Support for Personal PCK and Topic Specific Professional Knowledge**

The contribution of the three intervention scaffolds to the growth of the participants' personal PCK and topic specific professional knowledge is discussed in terms of Gess-Newsome's 2015 model (see discussion in Chapter 1). Five areas indicating growth emerged. The following section discusses those areas as well as how teachers' views and beliefs served to either filter or amplify participants' development in these areas. The 2015 model (See Appendix A), places teachers' beliefs and orientations

between the classroom practice component of personal PCK and topic specific professional knowledge. These categories are connected by double headed arrows signifying that each category has the potential to effect the other. In this chapter Gess Newsome discusses that some views and beliefs serve to increase the growth possible in both the classroom practice component of personal PCK and topic specific professional knowledge. This growth is designated as amplification. Other beliefs, however have the opposite effect, blocking or slowing growth and are designated filtering.

The following five sections examine findings from the participants' post demographic surveys, post lesson design tasks, transcripts of follow-up post interviews, and videos of the lesson modification portion of the PLCs. I also consulted my researcher journal to help bracket my findings. Each section introduces the main theme, gives specific examples from the data, and then discusses relevant components of topic specific professional knowledge as outlined in Gess-Newsome's model (2015). The themes that emerged are 1) how to design instruction, 2) the purposes of questioning, 3) strategies for delivering instruction, 4) progression of ideas, and 5) student thinking guides instruction.

### **How to Design a Lesson Plan**

The following excerpts illustrate how the combination of scaffolds helped the participants learn about effective lesson design. The following quotes illustrate the case's growth in this area. The first participant discusses her realization of the importance of noticing student thinking, considering how students will interact with the ideas in the lesson, and reflecting on lessons taught in guiding instructional trajectory.

From the intervention I learned about becoming a better teacher overall and just thinking about not only how to structure lessons but how to not think of the overall lesson but in-depth about how students going to interact with these ideas. Really pulling apart the lesson and even taking old lessons and looking through

them and examining student thinking. I never really thought about it...That's the point of teaching (post interview).

This comment also suggests the importance of content knowledge, representing pedagogical content knowledge category of content representation, in constructing effective lessons.

The next participant acknowledges an issue that many of the groups encountered as they struggled to enact a more constructivist pedagogy, frontloading information. As they became aware of the tendency to frontload and realized its detrimental effects, they were able to improve future lessons.

I definitely think that what we did for the study helps with the practical side of teaching. So all of this information about frontloading, I definitely learned from you and making that mistake in our lesson and fixing it for the following lesson (post interview).

The study's influence on practice built participants' personal PCK for teaching their specific topic in their specific context.

Finally, the last excerpt of this section suggests the idea that worksheet design is also an important component of guiding students to construct their own learning.

Worksheets will help them explore on their own and come up with their own ideas about what they think light is (post lesson design task).

In order to create effective worksheets that support student learning of the lesson objectives, teachers must develop sufficient knowledge of content representations and student assessment, which I categorized as an instructional strategy as formative assessment was the focus.

### **Purpose of Questioning**

This theme was a focal point of the intervention. Although initially all participants realized that questioning should be included in a lesson, their understanding of how and



why to incorporate effective questioning into their practice deepened, as illustrated in the following excerpt:

The main assessment I will use is questioning. I feel that proper questioning can lead to teacher understanding of students' thinking but also to students understanding themselves better (post demographic survey).

The participant acknowledges the two main purposes of questioning, formative assessment and pushing student thinking.

The next three excerpts focus on questioning while students are exploring during the hands-on portion of a lesson. The first excerpt highlights how teachers can use questioning to push students to formulate conclusions based on their observations using data they have collected, indicating a focus on authentic science practices.

Roaming, asking probing questions, assisting in recording observation and beginning to help students draw conclusions about what they are seeing (post lesson design task).

The next participant talks about pushing student thinking but also brings in the idea of helping the students make connections to other ideas in the unit, showing growth in content representation.

While students are working teacher will be asking questions so that the students really have to think about what is happening and how it connects to energy. These questions will make the students think deeper and maybe question some of the ideas they will be forming. This way they can try new things to see what is right (post lesson design task).

This excerpt demonstrates a move towards understanding how and why to provide constructivist based instruction.

The final response focuses on the participant's realization of the importance assessing why students think the way they do in order to perceive content representation from their perspective.

Probing questions are also important for observing student thinking because they allow teachers to understand why students think what they do rather than just guessing from their first observation (post lesson design task).

This quote exposes the realization that a deep level of analysis of student thinking is necessary to effectively teach.

### **Strategies for Delivering Instruction**

The case attributed instructional knowledge development to a combination of scaffolding that includes being introduced to both the 5E lesson plan format and the CER (claims, evidence, and reasoning) framework in the methods course as the following excerpt illustrates. . These strategies provide a template for allowing students to form their own understandings by exploring science concepts before connecting them to formal science constructs.

We got the CER framework and the 5Es from E328 (their science methods course). Science should be taught to children in way that they can come to their own conclusions. I did realize that but not how important that was until we talked about it in our PLC meetings. Not to frontload them, but to give them an experience that they can connect with the scientific kind of knowledge. That is important no matter how long it takes. Instead of you just stating it, which I know I still do, they (students) understand better if they arrive at those conclusions themselves. To have formative assessments to see what they're understanding and if they don't understand something then revise your lesson to provide more experiences for them to understand it, or if they get it move onto something else. I knew this before, but I feel it more firmly now (post interview).

While the participant learned about these strategies in her methods class, the intervention, and probably the field experience, deepened her conception of how science should be taught. This deeper view of how science should be taught illustrated growth of knowledge not only of instructional strategies, but of student understanding and content representation. Constructivist structuring of learning experiences provided opportunities for teachers to notice student thinking, which in turn led to evidence-based curricular decisions, providing the responsive instruction called for in reform documents.

The second excerpt refers to another important strategy in supporting student construction of scientific concepts, employing not just the right questions but also the right tools. For instance, when teaching the concept that liquids take the shape of their container, giving students different shaped containers to pour liquids into is essential. The following comment shows a deepened insight into the relationship between representation and experience.

We got to see how asking them the right questions and giving them the right tools you can get to the lesson that you were trying to explain without simply saying this is what it is and this is why (post interview).

This quote illustrates a growth in the knowledge that not only the questions asked, but the tools given, are instrumental in setting up effective learning situations. This demonstrates growth in knowledge of instructional strategies and student understandings and also in content representations.

### **Progression of Ideas**

The intervention supported the view that the order in which concepts are presented affects students' understanding of subsequent ideas. This key aspect of growing participants' topic specific professional knowledge especially student understandings and content representations, is demonstrated in the following excerpt of a conversation among one of the third grade groups following their lesson on white light. Here they are discussing that students had not grasped the concept that light is a form of energy and how the lesson might have been more successful with more attention to the order in which the concepts are presented.

Participant 1: I feel it would've made the whole light is energy thing more clear. They would have made that connection. I feel like that would potentially be a pitfall. We don't really know what they know about light being energy because we never had that conversation. We introduce the idea...

Participant 2: I wish we would've had like a whole lesson on light and energy

Participant 1: So I feel like just being clear about what the students think about, don't really know too much at this point.

Participant 3: That could be a modification, spending more time on energy and that light is energy.

Participant 1: I feel then that would definitely bring back in the shadows. We talked about earlier how we didn't really get the opportunity to talk about shadows being no energy. Honestly the heat light idea could have been a modification that we made.

Participant 3: If we were to modify it to switch to do light is energy first and then shadows after that.

Participant 4: Because it wasn't even light is energy... We would have had to add a lesson to our unit which is totally plausible if you are in your own classroom (lesson modification PLC 3).

Although the ideas about how properties of light, formation of shadows, and light as a form of energy are not completely accurate, this conversation captures the formation of the realization, based on their newly acquired noticing skills, that structuring the progression of ideas is an important consideration in building effective curricula.

### **Student Thinking Guides Instruction**

This final theme is central to the intervention, which was premised on the idea that professional noticing is essential to teaching effectiveness, and its enactment depends on topic specific professional knowledge. In the following excerpt, the participant discusses student understanding as the basis for deciding whether to progress to the next concept or review the present concept to ensure student understanding.

The intervention really helped with learning how to revise lessons. We sat down with our teaching team and talked about what worked well in our last lesson and how we could've done better and then putting it in our next lesson. With our group most of the time, since they [the students] weren't getting it, was just taking the same lesson and revising and then revision was our next lesson. Because the kids didn't understand we couldn't move on, just continue on the same concept but revising it in a way that would be better for them (post interview).

Inherent in this assertion are the principles that that one idea builds on the next and that student understanding should inform and guide lesson progression.

The final excerpt illustrates the participant's awareness of practical ways to accomplish assessment of understanding besides direct questioning or formal testing, as well as her knowledge of instructional strategies, student understandings, and content representations.

I will use a lot of informal assessments to see if students are understanding science. This can be done through exit slips, worksheets to follow a station, observing group work and asking for student created definitions (post demographic survey).

The excerpt corroborates growth in the participants' topic specific professional knowledge, by cataloging her arsenal of assessment strategies.

The next excerpt focuses on prompting and directing student thinking as an important instructional strategy, as well as why attending to student thinking is important.

Teachers' job is to direct students' thinking in the right direction (lead them away from misconceptions) to make students think deeper than surface level and help answer questions and help them make jumps in understanding for what students are struggling with (post demographic survey).

This quote also frames the teacher's role in correlation with a focus on student thinking.

## **Summary**

Each of the five themes that emerged when examining the data for evidence of growth in participants' personal PCK confirmed increases in each of the three topic specific knowledge components: instructional strategies, content representations, and student understandings. Additionally one of the themes, purposes of questioning, indicated growth in the topic specific professional knowledge component of science practices. As discussed in Chapter 1, growth in these components is influenced by the participants' views and beliefs, which in turn affect changes in participants' beliefs, creating a feedback loop.

As a result of experience with and reflection on practice-based strategies for delivering instruction such as employing the 5Es or the CER framework and utilizing both the right type of questioning and the right tools, the participants not only developed their personal PCK for teaching specific topics within specific contexts, but acquired topic specific professional knowledge, including instructional strategies, student understandings, and content representations.

The case's knowledge of the purposes of questioning developed as well, resulting from watching themselves teach and receiving feedback back from their peers and the content specific moderator. As their understanding of questioning deepened, they exhibited growth in their knowledge of topic specific instructional strategies and student understandings as well as of content representations and, in one instance, of science practices.

As the participants grew in their understanding of what needs to go into a high quality lesson plan that not only exposes student thinking so that teachers can make effective instructional decisions but also scaffolds students in constructing a framework of understanding, This development is then filtered through to the development of the topic specific professional knowledge. Thus, based on their experiences in constructing lessons responsive to students' needs, the participants started to build a framework on which to connect future topic specific knowledge. Additionally, as practice informs knowledge, so knowledge informs practice. Thus as their personal PCK developed, their professional knowledge base was also being established.

The remainder of this chapter is devoted to a discussion of these changes in participants' beliefs about teaching science and using noticing to inform practice, and

how these orientations either amplified or filtered the development of the preservice teachers' beginning PCK .

### **Changes in Beliefs**

To examine the changes in the participants' beliefs about teaching science, I drew from the pre and post demographics survey, the pre and post lesson design task, the transcripts of the pre and post interviews, and the exit slips from PLCs 1-4, as well as applicable statements recorded in my researcher journal entries after reviewing the previous data sources and my commentary on conducting the interviews and participating as a moderator in the PLCs 1-4. I begin with a description of participants' initial orientations and discuss how these had changed by the end of the study. The initial section draws from the pre demographic survey, pre-lesson design task and interviews, researcher journal entries covering those data sources, my thoughts on PLCs 1 & 2, and exit slips 1 & 2. The discussion of changes by the end draws from the post demographic survey, post lesson design task, post interviews, researcher journal entries on those data sources as well as PLCs 3 & 4, and exit slips 3 & 4. Although the case as a whole is the frame for the study, variations are indicated. Analysis uncovered four themes relevant to participants' PCK development and their ability to notice students' thinking: 1) beliefs about how science should be taught and effective strategies, 2) the teacher's role, 3) knowledge of students, and 4) knowledge of curriculum.

### **Initial Beliefs**

Even though participants initially professed a belief that science should be taught through inquiry, other beliefs such as attachment to frontloading and maintaining control acted as filters that hampered designing and enacting an inquiry based curriculum

supportive of noticing, as well as in the growth of their personal PCK and topic specific professional knowledge. Also the initial belief that a teacher's main role during group work is to keep the students on task interfered with efforts to provide a responsive curriculum. The participants' initial view that teachers only need to know about students' past experiences to determine what to teach acted as a filter for the participants' noticing skills and their personal PCK and thus also their topic specific professional knowledge. Their knowledge of curriculum also was very limited initially. For instance some participants did not even think to consult the standards in planning a lesson on light as part of the lesson design task. Finally their belief that many ideas can be included in a single lesson acted as a filter that hindered building student understanding and thus noticing as ideas could not be explored in depth. But as early as the second PLC, participants' beliefs about the teachers' role began to change to focusing on probing and pushing student thinking. This new belief, which favored the teacher's role as a facilitator of student learning, amplified their inclination to enact the type of curriculum that exposed students' thinking, enabling opportunities to provide responsive instruction. These ideas and how they changed over the course of the intervention are discussed below.

**How science should be taught.** Findings from multiple data sources supported the prevalent belief that science should be taught in an inquiry based manner that allows students to have hands-on experiences. The following collection of excerpts from several participants shows their belief in inquiry based pedagogy.

Believing this type of curriculum: “engages students and encourages independent thinking”, enables students to “explore questions for themselves and develop explanation for the questions” and that “learning about what interests them is important because it allows them to become passionate” (interview-pre).



However, at odds with this belief in the value of inquiry based teaching was the view that students should first learn the definitions to science terms before they begin to explore the ideas associated with the terms. This conflicting belief is demonstrated in the following excerpt from a participant in one of the third grade groups. Three of the four groups struggled with letting these views go.

I know we're not supposed to frontload but he didn't talk about refraction before so they literally didn't know that the experiment had anything to do with light. That's not frontloading, right? Just brought up as vocabulary.... (PLC 2).

This belief that it is necessary to first teach the vocabulary served as a filter for their personal PCK and topic specific professional knowledge, even though it also contradicts their initial view of inquiry-based teaching.

Other participants, especially the fifth grade group and one of the third grade groups believed that students would not grasp concepts they were learning without being explicitly taught. This concern is illustrated in the following excerpts from the second grade teaching group.

Participant 1: The only thing I think that is really hard about not frontloading is for our worksheet were all the things we were doing at each station ... but they (the worksheet set up) were just boxes. They (the students) had so many problems just writing down their observations

Participant 2: We didn't even observe a science lesson. We literally had no idea where these students were... That's hard when you're just dropped in there no idea where these students are and it was hard to adjust when you realized that they don't have these skills.

Participant 3: They struggle with that because at the beginning of our lesson before we showed the video, we're like- What is motion to you? They were like working out, and running. Even to get them on the right page, showing the idea is what got them in that right same mind we're talking about motion. We're not talking about running or swimming, we're talking about pushing and pulling.

Even though the participants acknowledged that they were frontloading and could identify where in the lesson they were doing it, they still held on to the belief that this tactic was necessary to help their group of students complete the worksheets by providing

background knowledge on the concepts first. The participants did not have faith that students would grasp the concepts through experiencing the concepts, even though their lesson set up was well organized with a preservice teacher at each station to guide each student's understanding, so s/he could explore each concept separately.

This lack of faith in the students' sense-making abilities could be the result of the preservice teachers having little or no concept themselves with how to connect students' exploration activity to formal science concepts. The only participants who mentioned this necessary component of inquiry-based teaching suggested reading a book or watching a video for making this connection.

I would start off doing an activity with a flashlight and shadows on the board. Then I would lead a discussion as to why the light does not travel through my hand and continue with the questions asked in question 3. Then I would show a video or use a textbook (depending on what is available to me) to show how light travels (lesson design task pre).

Although the majority of the participants espoused the belief that science should be taught through a hands-on inquiry approach, this belief that vocabulary must be learned first, prior to experiencing the concept, is actually what served as a filter when deciding how to approach their science teaching.

Another belief that prevented participants from enacting constructivist learning situations was allowing students to handle supplies would threaten the teacher's class control, as evidenced in the following exchange responding to the moderator's suggestion to allow students to handle the materials rather than just watch a demonstration.

Participant 1: I guess it would've been better if I gave them the materials and said show me how if I shined the light how it would travel across all the cards. That was a good suggestion.

Participant 2: I'm kind of afraid since mine (referring to her lesson) involves flashlights. I'm kind of afraid to give them flashlights because I feel like they're just going to go a little crazy (PLC 1).

Although insecurity about classroom management made her hesitant to incorporate this important component of inquiry based teaching, Participant 2 realized the benefits and bravely allowed students to handle the equipment in the lesson she led, resulting in the most effective lesson taught by this group. The experience changed the teacher's beliefs about lesson design and thus acted as an amplifier for her personal PCK for teaching in a learning cycle format, which in turn amplified her topic specific professional knowledge.

The participants' initial beliefs about how science should be taught conflicted with each other. While some of these conflicting beliefs served as filters for enacting inquiry based pedagogy, positive experiences with the approach served as amplifiers.

**Eliciting students' knowledge.** Initially participants held a superficial view of what teachers needed to know about their students in order to plan effectively. In the following excerpt, a participant expresses the belief that 4 out of 18 participants hold, that students' prior learning would enable teachers to gauge an appropriate starting point for their lessons without any reference to deeper probing.

I will need to consider the previous experience of my students. If they haven't worked with something or on a specific concept before that I will need to plan to include more of an introduction (demographic survey pre).

Although prior knowledge is an important consideration in lesson planning, it should not be the only consideration in deciding how to progress.

Another common belief, expressed by 6 out of 18 of the participants was that students' preferred learning modalities were one of the most important considerations in planning learning situations.

I think a variety (audio, visual, kinesthetic) presentations should be used so that students are given a choice and independence as to how to approach each scientific topic for themselves (demographic survey pre).

Although both prior learning and learning styles are important pieces of information in considering what to teach next, there is much more that a teacher needs to know about students' knowledge to make sound instructional decisions. For instance, ongoing assessment of the level of students' conceptual understanding is of prime importance. Thus participants' personal PCK and topic specific professional knowledge was initially filtered through a limited view of what constitutes an understanding of students' science knowledge.

**Knowledge of curriculum.** The participants' initial beliefs about planning curriculum were also naïve. For instance in the pre-lesson task analysis assignment which involved designing a beginning lesson on light for third graders, 6 out of 18 participants did not even consult the standards for what third graders are expected know about this topic in planning the lesson. Additionally 11 out of 18 participants outlined lessons packed with too many concepts per lesson. For example in a task given at the beginning of the semester in the methods course, one participant stated that her lesson objective for this introductory lesson on light would be to:

Define and look at the properties of light (transparent, translucent, opaque, absorbed, can be blocked, can be broken into colors, can refract and reflect) and then observe and describe how light is absorbed, changes its direction, is reflected back and passes through objects, Observe and describe that a shadow results when light cannot pass through an object (lesson design task pre).

Due to inexperience, these participants listed enough objectives for the introductory lesson as should be covered an entire unit, and providing the rationale for doing so as needing giving the students an overview of what they'll be studying so they know some of the terminology. This belief that you must present all the ideas initially to the students to then build the rest of the lessons served as a filter for how the teams organized and presented the rest of the learning experiences in their units.

**Teacher's role.** Initially most participants saw the teacher's main role as keeping students on task, which was a filter, although many also included the amplifiers of questioning and observing group work, as shown in the following response from one student on the lesson design task pre survey.

Question: While your students are working with the task you have planned, what will you be doing?

Answer: I will be going around the room making sure that the students are on task and asking them questions to get them thinking (lesson design task pre).

However, by the second PLC this view of the teacher's role was already beginning to change. For instance participants' comments on the second exit slip regarding how they perceived their role as a teacher, showed participants were beginning to embrace the teacher as a facilitator, prompter, and prober of students' thinking. For example, one participant wrote, "I will probe them and encourage exploration, I will guide them but not imply too much." Another commented, "As a teacher my role is to guide students' learning through facilitating discussion and probing their thinking further" (exit slip #2). These responses were typical, indicating the participants' germinating belief in the teacher's role as an amplifier for personal PCK as well as in guiding them in enacting a responsive curriculum.

Funneling, a questioning pattern that guides student understanding by asking a series of questions, was especially apparent in the advanced third grade light group's lesson on how light interacts with various media. The lead teacher, working with a small group of students exploring the effects of shining a light on aluminum foil, used funneling questions to lead the students' thinking to focus on how the foil created a shadow by blocking the light and then tasked them to explore the rest of the materials in the same manner.

Participants who were less advanced in their questioning techniques or in their understanding of how to probe student thinking effectively, which included all but one member of one of the third grade groups used the IRE (initiate, respond, evaluate) pattern of student/interactions and closed questioning (researcher notebook), acting as a filter for noticing. For example, in the following wrap up conversation about what they observed during their explorations of refraction, the students became stuck on the single observation that the object looked larger, and the teacher limited by this pattern of questioning was unable to move students past their misconception.

During this part of the lesson conclusion students definitely understood that light traveling through the water somehow changed how it appeared and made it bigger, however students were not able to grasp that light was refracting. Once James introduced the word and explained what it meant, some students were able to point out which places refraction happened in the experiment, but I think the majority of the students still were not able to clearly make sense of the concept. However, I don't think this is due to James missing student thinking; rather that light is just a hard concept for students to grasp, especially in only 40 minutes (individual reflection 2).

Both the teacher and the writer of the reflection exhibited an apparent lack of understanding of how the teacher could have funneled students' thinking to tie their observation to the larger concept. They realized there was a problem but did not know how to address it other than telling the students the answer directly. The participant reflecting on this interaction acknowledges that it was not effective, but attributes the failure to the students' readiness rather than the teacher's personal PCK for questioning (Gess-Newsome, 2015).

The themes emerging from analysis of participants' initial beliefs about teaching science depict a naïve belief system related to the role of the teacher, teaching strategies, knowledge of students, and knowledge of curriculum. For instance the participants'

staunch belief that science should be taught through inquiry reflected an idealistic view at odds with more entrenched beliefs such as the believed necessity of explaining concepts at the beginning of a unit and the individual lessons, as well as the belief that allowing students to interact with real world or messy materials may result in classroom management issues. Their initial personal PCK (i.e., knowledge of, reasoning for, and planning of a particular way to teach a topic) limited the role of the teacher to keeping students on task, placing an emphasis on gathering student knowledge as a means of determining prior experiences only, and emphasized learning of terminology over constructing a conceptual understanding. This initial orientation towards teaching science filtered how their personal PCK was enacted in the classroom context in the beginning (i.e., PCK and S or the Reflection in Action – see Appendix A) and helps to explain the limitations found in their early stages of professional noticing. However, over the course of the intervention changes in their beliefs about effective practices for teaching science began to occur. With these changes came differences in what ideas about teaching science filtered and/or amplified the translation process of their personal PCK (planning) to their PCK and S (enactment). Although changes in beliefs about the role of the happened as early as the second PLC, many more changes occurred in the second half of the intervention. Changes in orientation ‘by the end’ are discussed next. These changes are described in the following section.

### **Belief Changes over the Course of the Intervention**

All participants’ beliefs and ideas about how science should be taught became much more concrete. For instance what started out as a general belief in inquiry based teaching, progressed to include specific approaches to this type of instruction such as the

5E lesson plan format and the CER framework. Their beliefs were also tempered by the realization that inquiry may need to be balanced with explicit instruction to promote student understanding and that the practice of frontloading works against an inquiry philosophy. Participants' beliefs about the role of the teacher evolved even further from their initial view of teacher as manager to teacher as guide, expanding to include pushing student thinking and guiding constructivist learning situations. Finally their knowledge of curriculum also became more specific and student centered with a focus on the belief that curriculum and lesson design should be based on uncovering and pushing student understanding. All of these changes in beliefs acted as amplifiers for the participants' personal PCK and topic specific professional knowledge for providing a responsive curriculum for a particular science topic with a particular group of students.

**How science should be taught.** As the intervention continued, the participants' beliefs about how to teach science became more focused on the practical aspects of teaching, but also became more specific. For example when discussing how science should be taught, by the end the participants referred to the 5E lesson plan format and the CER framework. Both constructs were heavily emphasized in the methods class to help frame students' scientific thinking by emphasizing evidence-based claims and logical analysis of results. The following responses to the question of how science should be taught to children in grades K-6 illustrate how participants were learning to put the theories learned in their methods class into practice.

Participant 1: Students should be taught using the 5Es (engage, explore, explain, elaborate, and evaluate) Students need a chance to be engaged with the content they are about to explore through experiences. Students then need to be able to explain what they learned during their investigations. They need the chance to arrive upon conclusions for themselves with the support of their teacher and then chance to build on those conclusion. Lastly it is important for teachers to evaluate



their students to make sure that students have not arrived at false conclusions or misconceptions (demographic survey post).

Participant 2: I think science should be taught to children grade k-6 through the CER framework, the 5Es, and through hands-on explorations...The CER framework helps put the 5Es into a deeper perspective. When students are discussing and filling out their claim, they are deciding what they think the investigation is about. Once they find out and write down their evidence from the exploration that allows them to answer their claim, they are then able to reason through why it happened and what it means (demographic survey post).

As participants formed a more practical, detailed understanding of how science should be taught, their new beliefs about how students learn acted as amplifiers for their personal PCK and their topic specific professional knowledge.

The case's practical understanding led to the belief that there needs to be a balance between inquiry and explicit instruction, but that exploration should come before explicit instruction, and that frontloading gets in the way of student exploration of ideas and therefore of students' conceptual understanding.

Through this course I have learned the importance of not "front-loading" the information to the students. This will extremely limit their discoveries and knowledge acquisition as they work hands-on with the materials given (post demographic survey).

Participants began to believe in the power of the learning cycle lesson design that allow students to have hands-on exploration followed by an explain phase to guide students to construct ideas from their experiences in the explore phase (post lesson design task).

These ideas also served to amplify personal PCK and topic specific professional knowledge. Even reticent participants were starting to realize that open inquiry needs to be supplemented by the teacher's solid understanding of the science content and enactment of noticing skills to assess where explicit instruction is needed so s/he can confidently support students' construction of accurate scientific understandings.

I think there has to be a balance between inquiry based and more explicit instruction. When I was writing my final paper for science last night, I was

realizing that maybe having something be total inquiry just leaves it open to misconceptions and so it's good to start with an inquiry and have them work toward the questions but if they don't get it or don't understand the connections... then you're there to show them those connections (post interview transcript).

This excerpt also shows how participants' beliefs became both more detailed and practical. In the final paper for her science methods course, this participant reflected on how her beliefs about teaching had evolved as a result of planning and participating in teaching experiences along with the support of the intervention scaffolds. These more detailed, practical beliefs based on experience served to amplify participants' personal PCK and topic specific professional knowledge for enacting an inquiry based pedagogy.

**Teacher's role.** The case's beliefs about the teacher's role evolved from seeing it as keeping students on task to viewing the role primarily as uncovering and pushing student thinking. They also discussed the importance of a teacher's guidance in orchestrating effective inquiry based instruction. Finally participants discussed the belief in the importance of formatively assessing through questioning, especially while students are exploring.

During the exploration phase, I will be walking around the room, checking in on groups, either assisting them/giving them additional guidance if needed but mostly probing their thinking further by asking probing questions. I would also be on the lookout and taking note of students' ideas and understanding (post lesson design task).

This comment about the importance of ongoing formative assessment also shows awareness by the case of the teacher's strategic role in taking advantage of the explore phase as an optimal time for such assessment. Participants also expressed the belief that the teacher can use directed and purposeful questioning to clear up misconceptions. Additionally they acknowledged that probing once may not be enough. These new beliefs acted as amplifiers for providing learning cycle lessons. On the other hand, 2 of the 18

participants expressed their belief there was not enough time to confront misconceptions by planning different experiences and that the only way to ameliorate students' confusion was to review ideas or post vocabulary items. These beliefs acted as filters for accomplishing a responsive curriculum.

**Knowledge of curriculum.** The case's beliefs about curriculum also became more specific and directed as the weeks progressed. As illustrated in the following excerpt, expressing the belief that curricular decisions and lesson design should be based on student understanding.

I think you need to consider how involved the students were and how well they understood the topic you taught them. If students weren't involved and engaged then they were probably bored and didn't get much out of the lesson. If the students didn't understand what you taught to them then you need to modify the lesson and change what you are doing (post demographic survey).

This quote details the belief that students need to demonstrate an understanding of the material before the teacher decides to move on to the next concept. The participant's newly developed skill for noticing is amplifying the importance of considering student thinking when deciding next steps for instruction. Even the fifth grade group who struggled with giving up the idea of frontloading realized this was an important consideration. They ended up changing their fourth lesson to review three foundational ideas (mass, volume and weight) instead of moving on to a more advanced topic (conservation of matter).

As the excerpt below illustrates, the participants also began to realize that building assessment into lesson design can facilitate both student understanding and teacher assessment of that learning.

I know learning is occurring in the classroom through the students' responses to questions. Also when they are given a worksheet their answers are a view of what they know. (Exit slip from PLC 3)

This realization that student learning can be determined through questioning as well as by consulting student responses on worksheets portrays an increased sophistication in not only topic specific professional knowledge but in the overarching generalized teacher professional knowledge bases.

The next excerpt details the importance of designing instruction to maximize learning.

How to research about your topic and gather the correct supplies to make your lesson the best it can be (exit slip 4).

These types of modified beliefs about ways to stimulate and assess student thinking and understanding amplified participants' personal PCK and thus their topic specific professional knowledge over the course of the intervention.

**Summary.** In all areas, the participants' beliefs changed to become more complex and in line with pedagogy that facilitated the acquisition of noticing skills. The participants progressed from a general belief in inquiry to a specific belief that science should be taught to elementary students using a learning cycle lesson format and through inquiry involving students in creating evidence based claims. Their beliefs about the teacher's role also evolved from that of a manager to that of a facilitator uncovering and guiding student thinking. Similarly, they progressed to the belief that curriculum planning should be based on student understanding, which supported the importance of noticing student thinking in order to provide a responsive curriculum. These changes in beliefs all reflect amplifiers. These amplifiers all served to move participants to more advanced

levels of noticing as well as assisted in developing their personal PCK and topics specific professional knowledge.

## CHAPTER 5

### CONCLUSIONS AND IMPLICATIONS

To effectively meet students' needs, educational reform in science calls for an adaptive, responsive curriculum based on eliciting what students are thinking. To gain an understanding of what students know, a teacher needs to attend to, probe, and analyze student thinking. This then provides information on which to base curricular decisions. These steps comprise a skill referred to in the literature as *professional noticing* (van Es & Sherin, 2002). None of the steps involved in noticing - attending to, analyzing, or deciding what to do - come easily. These skills difficult for any teacher, can be especially difficult for preservice teachers, who lack the experience these skills require (Davis & Smithey, 2006). Additionally, inadequacies with preservice teachers' personal PCK and topic specific professional knowledge may limit their responses to students' thinking.

In response to this problem, my study investigated how a three-pronged scaffold, consisting of video based reflections of preservice teachers' own classroom practice, a preservice professional learning community (PLC), and a content specific moderator, served to guide the preservice teacher participants in learning to professionally notice to develop their pedagogical content knowledge (PCK) for teaching science in order to provide a responsive curriculum. Given the structure of this approach, three research questions were posed to guide the study.

1. How do the abilities to professionally notice students' scientific thinking develop as the preservice elementary teachers in this study participate in a four-week, moderator-led, professional learning community (PLC) featuring video-based reflections on practice, and to what aspects of the three scaffolds do participants attribute this development?

2. How do the participants use what they have learned about student thinking to modify their instruction, and to what aspects of the three scaffolds do they attribute this change?
3. In what ways does the combination of these three scaffolds set within the context of a methods course affect the preservice teachers' development of their personal PCK and topic specific professional knowledge?

This chapter is organized beginning with a summary of the major findings for each question, followed by an overall discussion of the significance of these findings with respect to the literature. I then conclude the chapter with contributions of this study followed by implications for science teacher educators and finally suggestions for further research related to the investigation of the practicality of the three-pronged approach in other teacher education (preservice and inservice) contexts.

### **Summary of Findings**

Results of the participants' abilities to notice are discussed in terms of what they noticed, how they noticed, and to what aspects of the scaffolds they attributed their changes. I discuss my findings in reference to the four levels outlined in van Es' 2011 framework for noticing (see Table 1).

Initially the majority (17 out of 18 participants) of *what* the preservice teachers noticed was more general in nature, as they paid attention to the class as a whole rather than individual students' thinking (Level 1). One of the participants was more advanced initially attending to individual students' thinking as well as to pedagogy (Level 2). However, near the end of the intervention 10 out of 18 participants were just beginning to attend to individual student's thinking -Level 2, three had progressed to Level 3 and

were focusing primarily on specific students' thinking) and six had progressed to connecting those ideas to specific teaching strategies indicative of Level 4. With regards to *how* the participants noticed, initially the majority (10 out of 18) participants did so in a general evaluative way (Level 1), while 8 out of 18 were already focusing on specific interactions in an interpretive way (Level 2). However, near the end while four participants had only progressed to noticing specific noteworthy events (Level 2), the rest (14 out of 18) were making connections between events and principles of teaching and learning, as well as proposing valid alternative pedagogical strategies (Level 4).

Participants attributed learning to recognize critical incidents, assess their own teaching, and probe student thinking to the video component of the intervention. They credited learning to analyze critical incidents and deciding next steps to the PLC and learning content, connecting theory with practice, and receiving content knowledge and pedagogical advice to the subject specific moderator. Although the participants acknowledged the contributions of specific scaffolds, they realized that the combination helped them learn to structure their instruction to provide a responsive curriculum.

As to *how the participants used* what they noticed to modify their planned curriculum (i.e., the second research question), the data revealed a move from frontloading information and sticking to pre-existing plans to discussing both content and pedagogical strategies that would be effective in helping students achieve lesson objectives. However even as the preservice teacher participants were improving their probing of student ideas, 3 of the 4 groups were still reverting to didactic pedagogy when addressing students' misconceptions. By the end of the intervention however, participants stated that they realized the importance of setting up ideas to build upon each other and



were starting to learn how to effectively design constructivist learning situations to support this type of learning.

All of the participants expressed the conviction that the scaffolds helped them learn to modify curriculum based on student thinking. Participants attributed assessing student understanding and uncovering more areas for improvement to video based reflection. While they credited assessing how students were struggling and solving problems in their practice to the support of the PLC and learning to construct learning experiences to the content specific moderator. Additionally they saw support of the combined guidance of the three scaffolds in addition to contributions from their methods class and the field experience as providing a forum for learning to notice, learning probing skills, and identifying what aspects to consider when revising lessons.

With respect to the final research question, five themes emerged from my analysis of how the intervention developed participants' personal PCK and topic specific professional knowledge: 1) how to design instruction, 2) the purposes of questioning, 3) strategies for delivering instruction, 4) progression of ideas, and 5) instruction guided by student thinking. These five themes structure the growth fostered by the combination of intervention scaffolds, both in the participants' personal PCK and in their topic specific professional knowledge. As participants' understanding of questioning that exposed student thinking deepened, they learned to create lesson plans that supported students with the act of sense-making about the concepts (Zangori, Forbes, & Biggers, 2013). As a result of gaining experience with reflection *on* the action of teaching (i.e., personal PCK), they developed practice based strategies for delivering instruction such as employing the 5Es or the CER framework and utilizing the right type of questioning as well as the right

tools. Participants' realized that careful structuring of the progression of the science ideas is crucial for helping students build a solid framework of understanding. This realization reinforced their awareness of the importance of using student thinking to guide instruction, which was also linked to the development of a more sophisticated view of assessment. Each of the five themes that emerged when examining the data for evidence of growth in participants' personal PCK confirmed increases in each of the three topic specific knowledge components of: instructional strategies, content representations, and student understandings (see Appendix A). Additionally, one of the themes, purposes of questioning, indicated growth in the topic specific professional knowledge component of science practices.

Both personal PCK and topic specific professional knowledge growth were influenced by changes to the participants' beliefs about science and the teaching of science. Their beliefs served to filter or amplify their thinking and decision-making about instruction depending on how committed the participants were to a particular belief or how willing they were to embrace changes in their beliefs. In all areas, the case's beliefs changed to become more detailed and in line with reform based pedagogy facilitating the acquisition of their noticing skills. The reverse however was apparent as well, showing that their experiences with instituting reform based pedagogy amplified the acquisition of reform based beliefs creating what Thompson (2005) called a "virtuous circle" (p. 152).

All participants progressed from a general belief in inquiry to a more defined, explicit belief that science should be taught in a learning cycle lesson plan format that involves students in creating evidence based claims. Their belief in the teacher's role

evolved as well, moving from one focused on classroom management to one based on uncovering, guiding, and pushing student thinking. Furthermore their beliefs progressed to a conviction that the trajectory of the curriculum should be driven by student understanding. Embracing these changes in their beliefs served as amplifiers resulting in incorporating changes in their practice as their teaching in the field experience progressed. However, 3 of the 4 groups still fell back on didactic pedagogy when faced with persistent student confusion. Thus the reform-based, constructivist approaches associated with conceptual change theory that the participants were learning about in their science methods course were rejected. In this case, as participants held onto the belief that didactic approaches would best address student misconceptions, this created a filter for adopting reform based practices. These examples demonstrate the power that beliefs about teaching can have on the translation of theory into practice.

However, near the end of the intervention, participants had developed a much stronger belief in the role of professional noticing for informing practice which acted as an amplifier for developing their decision-making skills for how to modify subsequent lessons based on students' thinking. The amplification caused by this belief about the role of professional noticing positively influenced participants' ability to use questioning and formative assessment to determine student understanding and decide next steps in their practice. Unfortunately, as previously mentioned, their beliefs and repertoire of instructional strategies for how to respond to students' incorrect or alternative ideas were limited and their decisions about what to do next were filtered through the belief about the efficacy of didactic teaching methods. This finding of opposing beliefs supports Pajares (1992) description that teaching beliefs are a 'messy' construct and are important

to consider when understanding how teachers' knowledge is (or is not) translated into practice (Gess-Newsome, 2015). Understanding the ways in which beliefs can act as filters or amplifiers for teachers when making decisions about what pedagogical practices to accept or reject in their teaching can help teacher educators and/or professional developers rethink their own pedagogical content knowledge for working with science teachers.

While not all participants' noticing skills, including what and how they noticed, progressed to the same level, they all showed progression in some way towards more reform based practices. This was particularly true for how they used what they noticed to make curricular decisions as their time teaching in the field progressed. Growth was also evident with respect to participants' personal PCK and topic specific professional knowledge development; although, once again, the growth varied as influenced by participants' beliefs about teaching science acting as either filters or amplifiers for enacting reform based pedagogy. In the following section I explain how growth in these areas correlates with the existing literature.

### **Discussion**

Each area of the three pronged intervention utilized in this study informs a critical gap in the literature. For instance, this study points to the effectiveness of using video of the preservice elementary teachers' own teaching to assist in developing their professional noticing of students' scientific thinking. The study also starts to uncover how professional learning communities focused on the practice of professional noticing work within the context of preservice teacher education. Additionally, the intervention illuminates the benefits of using a content specific mentor, with a role similar to that of

an instructional coach, to scaffold instructional decision-making within the context of science education. Finally, comments provided by the participants regarding the three scaffolds pointed to the value of the combination of scaffolds for supporting the kind of advanced professional noticing some of the participants had acquired by the end. This accelerated acquisition of noticing skills in turn promoted these participants' PCK development.

The following sections describe critical contributions from this study to the existent literature with respect to how to scaffold professional noticing for planning a responsive curriculum as well as how to assist in developing preservice teachers' personal PCK and topic-specific professional knowledge for doing so.

### **Noticing**

Similar to what is documented in the literature, all participants' noticing skills grew as they progressed from describing what occurred (level 1), to a focus on their own teaching (level 2). Fifteen out of eighteen were even targeting students' thinking and analyzing lesson outcomes by connecting teaching strategies to student thinking (levels 3 & 4) (Jacob, Lamb, & Phillips, 2010; van Es, 2011). Friel and Carboni (2000) documented similar pattern with preservice teachers initially focused more on themselves than on what their students were thinking.

How they were noticing in the intervention also followed the trajectory established in the literature, moving from the evaluative stance of judging (level 1) to a more interpretive one using reasoning based on evidence (level 2). By the end the majority (14 out of 18) had progressed to connecting incidents to overarching teaching principles by making connections between events and principles of teaching and learning

(level 4) (van Es & Sherin, 2002, van Es, 2011). This ‘in the moment’ decision making requires teachers to analyze what they are seeing in the classroom and connect it with what they know about teaching and learning (Lampert, Beasley, Ghousseini, Kazemi, & Franke, 2010). This ability to connect teaching and learning can lead to effective decision-making while in the act of teaching.

Friel and Carboni (2000) found, as I did, that even though the preservice teachers understood conceptually that they should pay attention to students’ thinking, they did not immediately realize this information should be used to help them make instructional decisions. As I observed at the beginning of the intervention, although participants knew attending to student thinking was important, they designed curriculum which frontloaded information and were reluctant to stray from existing plans. Also, even as they were learning to probe student thinking they still fell back on employing didactic pedagogy when confronted with student confusion or misconceptions.

However, by the end, the participants in my study had grown in their practical knowledge to the point that they could recognize that the way they set up learning situations had bearing both on exposing students’ thinking and in allowing students to construct their own understandings. Along with this they realized that the way they sequenced concepts was also an important consideration. Both of these advanced ideas were premised on the principle that attention to student thinking should guide instructional decisions, indicating the efficacy of the intervention scaffolds in building participants’ noticing skills as well as their personal PCK and topic specific professional knowledge for teaching science.

The participants attributed this advance in abilities to the combination of the scaffolds in the intervention. Considering these findings, I propose an extension to van Es' 2011 framework for noticing that details a progression on how teachers may develop their ability for learning to respond to noticing (see italicized row in Table 4). This added section is important to consider when working with preservice teachers in developing their ability to professional notice because it outlines their level of progression as they learn how to act on what they notice. This section also acknowledges and delineates the filtering or amplifying effects of beliefs on the teachers' growth. This information is useful to consider when trying to understand how teachers' knowledge is or is not translated into practice.

### **Support Provided by Intervention Scaffolds**

Participants attributed learning to recognize critical incidents to reflecting on videos of their own and others' teaching. This extends Star and Strickland's (2008) assertion of the positive effects of video on developing preservice teachers' observational abilities because the scaffolds put into place in this study shows how the combination is what helped the participants to move beyond simply developing their observational skills, but also their decision-making skills regarding instruction. The progression of skills also corroborates benefits outlined in Sherin and van Es' (2005) study of a video support tool called VAST, which was effective in developing the ability to notice, probe, analyze, and assess students' thinking as well as apply the information to subsequent planning within mathematics education. Sherin and van Es discuss the role of video in scaffolding teachers' responses to student thinking. The participants attributed the input of video, especially when enhanced with collaborative reflection, as was supported by the PLCs in this study, to giving them the opportunity to reflect on interactions without the restrictions of real-time classroom situations, which allowed time for

Table 4  
*Framework for Learning to Notice and Respond to Student Scientific Thinking*

Modified from: Framework for learning to notice student mathematical thinking (van Es, 2011, p.139)

	Level 1 Baseline	Level 2 Mixed	Level 3 Focused	Level 4 Extended
What Teachers Notice	Attend to whole Class environment, behavior, and learning and to teacher pedagogy	Primarily attend to teacher pedagogy  Begin to attend to particular students' scientific thinking and behaviors	Attend to particular students' scientific thinking	Attend to the relationship between particular students' scientific thinking and between teaching strategies and students' scientific thinking
How Teachers Notice	Form general impressions of what occurred  Provided descriptive and evaluative comments  Provide little or no evidence to support analysis	Form general impressions and highlight noteworthy events  Provide primarily evaluative with some interpretive comments  Begin to refer to specific events and interactions as evidence	Highlight noteworthy events  Provide interpretive comments  Refer to specific events and interactions as evidence  Elaborate on events and interactions	Highlight noteworthy events  Provide interpretive comments  Refer to specific events and interactions as evidence  Elaborate on events and interactions  Make connections between events and principles of teaching and learning  On the basis of interpretations propose alternative pedagogical solutions
<i>Responding to noticing</i>	<i>Frontloading terminology or concepts</i>  <i>Attachment to existing plans</i>  <i>No true understanding of reform-based practices</i>	<i>Discussing pedagogy &amp; subject matter</i>  <i>Confronting misconceptions with didactic pedagogy</i>  <i>Reform-based practices understood but filtered by prior beliefs about teaching especially when making instructional decisions</i>	<i>Probing with more detailed questioning to target specific curricular needs</i>  <i>Reform-based practices are amplified through the acceptance of reform-based beliefs.</i>	<i>Plan curriculum so concepts build sequentially</i>  <i>Starting to employ constructivist learning situations</i>  <i>Reform-based beliefs are not only amplified but translated into practice.</i>



important processing and metacognition (Borko et al., 2008). Participants also felt this in-depth reflection enabled them to become aware of other areas in their teaching needing improvement. The literature discusses changes in focus as video reflection turns teachers' attention away from themselves and towards listening to student ideas (Friel & Carboni, 2000; Towers, 1998). Participants reported this benefit by describing video's contributions to their skills of recognizing important junctures and probing student thinking.

My study points to the application of effects seen in mathematics education within the preservice elementary science context. Although not explicitly attributed by participants to the video component of the intervention, the progression of their levels of noticing skills (van Es, 2011) was evident. For instance, Rosaen et al.'s 2008 assertion that video allows a moment in time to be viewed repeatedly to glean the importance of certain events (level 3), aligns with benefits outlined by participants in my study. Additionally the changing focus from management to instruction within both in my participants and those in Rosaen et al.'s 2008 study, corresponds with a level 2 noticing. Finally, my study shows the benefits of focusing on discourse as a useful source of evidence for claims, as did Roth et al. 2011. This finding, which relates to levels 3 & 4 in van Es (2011) framework for noticing, demonstrates how these practices are attainable by preservice as well as inservice teachers when given the to the appropriate support to reflect on their own practice within a real classroom context.

The findings show the participants identified me, the content specific moderator or instructional coach, as a useful component of the intervention with respect to bridging theory and practice. In this role, I was able to support preservice teachers in learning to teach science in ways they had not experienced themselves as learners (Darling-Hammond & McLaughlin, 1995). I was also able to emphasize and model practices for teaching science that focused participants' attention on observing and interpreting students' thinking. That the moderator or content coach was critical to the whole scaffolding process implemented in this study demonstrates the need to

have someone integrally involved to support topic specific content knowledge for teaching (Abell, 2007; Gess-Newsome, 2015). This idea is discussed further in the next section.

They felt reflecting on videos of their teaching in the context of a professional learning community provided multiple viewpoints helping them envision alternative pedagogical strategies (Borko, Jacobs, Eiteljorg, & Pittman, 2008). Santagata and Guarino (2011) assert that guided video viewing provides the modeling necessary to focus preservice teachers on important aspects of teaching. The present case study supports this assertion by describing how the case felt the combination assisted them in learning to how to structure their lessons and in what to consider in revising them, as well as in considering next steps. Van Es and Sherin (2005) reported “changes over time in what teachers noticed and in how they interpreted events” (p.475) in their study involving video clubs which combined video reflection and professional communities similarly to the intervention in the present study. Finally the participants attribute the beneficial effects of the PLC for providing a forum for learning to notice and probe student thinking and for assessing where students were struggling, in other words to help them solve problems in their practice.

Thus participants saw the merits in the scaffolds both individually and in combination in helping them to learn to professionally notice as they built their personal PCK and topic specific professional knowledge for teaching science.

### **Personal PCK and Topic Specific Professional Knowledge**

Due to the lack of development in preservice teachers’ PCK they do not have the proficiency to make sense of learning situations as do experienced teachers, so they miss a great deal when observing (Friel & Carboni, 2000). Knowledge of context is important in interpreting interactions and in using those interpretations to guide pedagogical decisions (van Es & Sherin, 2002). My input as the subject specific moderator and experienced teacher who watched all teaching group videos helped support growth in this area.

The intervention's effects on the participants' personal PCK and topic specific professional knowledge were connected to their need for extensive guidance and to the feedback loop that developed between their growth in noticing and their PCK (Gess-Newsome, 2015). Calderhead (1989) observed that many of the reflective activities preservice teachers are asked to complete are beyond their capabilities, necessitating extensive guidance. In this study guidance was provided by the combined effect of the scaffolds working to guide participants in learning to adapt their instruction to meet the students' needs (Avramidou & Zembal-Saul, 2010; Davis & Smithey, 2009; Hollon, Roth, & Anderson; 1991). Roth, Garnier, Chen, Lemmens, Schwille, and Wickler (2011) utilized long term collaboration within a real context in their professional development focused on scaffolding teachers in both content knowledge and pedagogy. My intervention, although not long term, reaped similar benefits for the preservice teachers' development of personal PCK and topic specific professional knowledge. Roth et al. 2011 focused on four strategies in their PD: 1) eliciting student ideas and predictions, 2) asking probing and challenging questions, 3) having students interpret and reason about observations as data, and 4) asking students to make connections through summarizing and synthesizing work. These four areas only partially cover two of the five areas to which my intervention contributed. The two areas where my study overlaps with theirs are a) how to design instruction and b) the purposes of questioning. Due to the extensive support provided in this study, additional benefits of this intervention included: scaffolding of strategies for delivering instruction, the importance of the progression of ideas, and the guiding tenet that student thinking guides instruction.

Initiating the development of teachers' personal PCK and topic specific professional knowledge in the early stages of a teacher's career is important because it gives them a foundation from which to continue building their knowledge and skills for implementing reform based (i.e., constructivist and inquiry-oriented) practices in their classrooms. In the preservice phase of their professional development, teachers need experiences acquiring subject matter knowledge, knowledge of science learners, and knowledge of topic specific pedagogies, while

being immersed in real classroom contexts. This opportunity to contextualize their experience allows them to develop “deep conceptual understandings of learning goals while also conveying the nature of science by engaging students in authentic scientific inquiry” (Davis, Petish, & Smithey, 2006, p. 609). Preparing preservice teachers for the demands of the profession in this way will not only help them be successful in enacting this type of pedagogy, but may also help to counteract the prevalence of attrition (Davis, Petish, & Smithey, 2006). Thus the combination of the three intervention scaffolds situated in the authentic context of classroom practice served to foster the participants’ personal PCK and topic specific professional knowledge for teaching science in an accelerated way.

### **The Power of Beliefs**

Teachers’ views are influenced by the particular lenses formed by their experiences, suggesting the importance of providing them with the kinds of experiences that encourage them to notice their students in certain ways (Jacobs, Lamb, and Phillip, 2010). The notion of the amplifying or filtering effects of beliefs presented in the Gess-Newsome’s 2015 model of teacher professional knowledge was evident in my findings. Many beliefs, such as the belief that science should be taught in a constructivist manner served to amplify participants’ noticing and personal PCK and by extension their topic specific professional knowledge. Other beliefs worked as filters such as their belief in the necessity of frontloading information. Reflecting on videos of their teaching helped the preservice teachers reconstruct their orientations and beliefs about how children learn, moving them from a didactically focused, to a more child centered pedagogy. The practice also created constructive dissonance, causing preservice teachers to confront their preconceptions and misconceptions, and advance their understanding of teaching and learning (Rosaen et al., 2008). Meyer (2002) submits, “Novice teachers need opportunities to talk with others about the teacher they want to be given the students they teach and the context within which the work” (as cited in Leite, 2006, p. 7). The intervention provided them with the opportunity to do just that.

In acknowledgment of the role that beliefs play in the way that teachers respond to noticing, I have incorporated the results of my findings into the van Es (2011) framework for noticing (again, see italicized row of Table 4). In the ‘Responding to Noticing’ section of this table there is a progression of skills ultimately resulting in the enactment of reform based practices. This progression starts with participants not having a true understanding of reform based practices (level 1); to developing an understanding of these practices but retaining attachment to prior beliefs thus filtering their incorporation (level 2); to practices being amplified through the acceptance of the benefits of these practices (level 3); and finally to these practices not only being amplified but enacted. The addition of this row to the table contributes to the literature in science teacher education, reflective practice, and the effect of teacher orientations on teaching and learning. Finally it serves to combine the research on noticing with the new research on PCK (Gess-Newsome, 2015). Specifically the inclusion of considering beliefs as filters and amplifiers as a way of understanding how one responds to what they notice is important for guiding science education in addressing this important consideration while informing both preservice and inservice professional development.

### **Conclusions**

The three-pronged scaffold at the core of the intervention in this study was found to be effective in helping the participating elementary preservice teachers with developing their abilities to notice students’ scientific thinking. The combination of video-based reflection, participation in a PLC, and the support of a subject specific moderator, which were separately proven to be useful in other contexts were determined useful in combination within this context of science teacher preparation. Although some participants progressed farther and more quickly in their noticing skills than others, the fact that all progressed in some way is encouraging and suggests that with a longer time frame perhaps there would be even further progress. The modification made halfway through the intervention, of replacing whole class discussion with a guided process for determining what to do with information gained from noticing students’

thinking, seems to have given participants a clearer focus and increased their comfort level with sharing what they were noticing. They were able to concentrate and build their own knowledge (personal PCK) of how to teach their particular topic within their particular context, which in turned enhanced the more general topic specific professional knowledge. This concentrated focus on a specific topic and context helped to build not only their noticing skills, but also their personal and topic specific PCK.

Two significant insights resulted from this study a) in order to build noticing skills preservice teachers need to be scaffolded in also developing their PCK and b) the combination of the three scaffolds is critical to this process. Besides learning how to probe and assess thinking to gain a deeper understanding of what student do and do not understand about concepts, novice/preservice teachers need support in understanding how to create learning situations that both expose students' thinking and allow students to construct their own knowledge. They also needed guidance in narrowing down concepts covered in each lesson and in structuring their lesson progression so that ideas build on each other. These needs suggest that scaffolding should have begun earlier on so such issues could have been addressed before the teaching portion of the field experience began.

Evidence showed the combined efforts of the three pronged approach employed in this study provided the necessary supports for this learning to occur, or at least to initiate awareness. The three scaffolds worked together to support the participants' growth in learning to notice and in their personal PCK and by extension their topic specific professional knowledge. The experience of reflecting on their group's teaching allowed participants to form solid understandings of instructional strategies, content representations, student understandings and science practices. This movement between general knowledge of current best practices (topic specific professional knowledge) and specific attention to their own teaching and their students' thinking (personal PCK) was actually a back and forth process improving both. Participants' growth was also influenced by the their views and beliefs which served to either filter or amplify

the knowledge to base decisions about teaching and their progression in learning to professionally notice.

A final insight provided by the study was that I was also guilty of frontloading information. Swayed by the short timeframe for teaching the participants to notice and my desire that their teaching experience be a positive, successful one, I perhaps offered too much help. I told participants ways to structure activities to expose student's thinking and allow student to build their own ideas, I directed them about what made sense to teach next, while I coached them on how to avoid frontloading. As I was urging the participants to employ reform based pedagogy I was doing in fact reverting back to didactic pedagogy myself; a practice that may not have allowed the participants to construct a solid understanding of the concept of using professional noticing to inform practice.

### **Implications for Science Teacher Educators**

Given the progress in the participants' noticing skills, personal PCK, and topic specific personal knowledge found in this study, I recommend that science methods and field experience courses include video based reflection of preservice teachers' own teaching to help build their PCK for attending to student thinking and to help in tying theory to practice. The use of such videos to encourage self-assessment and collaborative critique within the context of a preservice PLC aligns with the principles of constructivist pedagogy (Abell, 2007). The support provided by this type of guided reflection, combined with the scaffolding provided by a subject specific moderator, can help students build the metacognitive skills necessary for effective classroom practice (Donovan & Bransford, 2005). Therefore, I suggest that science teacher educators institute this three-pronged scaffolding structure to help preservice teachers develop the skills of attending to student thinking and in using the information to make instructional decisions, either on the spot or in designing future lessons.

Furthermore, I suggest special attention be paid to conveying the reasoning behind and the construction of reform based practices early on, as the preservice teachers are conceptualizing

and designing their units. Another practical consideration is allotting more time for preservice teachers to figure out how to modify curriculum based on what they have noticed. Also the methods instructor or moderator should be cognizant and vigilant of too much frontloading of information. Constructivist teaching needs to not only be espoused by the teacher educator but modeled through their own practice.

### **Recommendations for Further Research**

While this study points to the usefulness of employing video-based PLCs that focus on the use of the preservice teachers' own teaching and incorporates a subject specific moderator, there are limitations with the study presented and thus many questions remain. First, the application of this combination of scaffolds within a variety of contexts needs to be investigated in order to increase its generalizability. Second, the study does not address the long term retention of gains documented within a four-week intervention; without the supportive environment of the content specific moderated PLC there is the possibility of reverting to other concerns at the expense of attention to students' thinking. Third, structuring the intervention to encompass both the lesson construction and teaching portion may have had greater effects on their abilities to notice and their PCK growth. Furthermore increasing the amount of time to incorporate changes decided upon during the PLC meetings may also have the beneficial effects, a possibility that future research may investigate. Finally, the question remains of how amplification of beliefs can be harnessed to improve this trajectory even further.

While there are many aspects about the intervention that needs to be further investigated the promise this type of approach shows from this single case study is noteworthy. Therefore, to build on what was found with regards to the potential of the approach further research is need to identify ways to maximize amplifying and minimize the filtering of reform-oriented beliefs, as well as strategies for how to incorporate models of professional noticing, as was the intention of the whole class review session of videos initially, so that participants are actively engaged in the modeling process. With respect to the latter need, a suggestion is to set up coaching sessions a



couple of times through the intervention (i.e. at the beginning and 2/3 of the way through their science teaching) where the moderator meets with each team outside of class to examine a 10-15 clip in detail may serve to tailor instruction to each group's needs while reducing the stress of participating in whole class viewing. The section chosen could target the explain phase in order to focus on where sense-making occurs and an area preservice teachers typically find difficult to implement (Zangori, Forbes, & Biggers, 2013).

Finally, the idea of how to scaffold preservice teachers' noticing while still maintaining constructivist pedagogy within the short time frame of teaching a science unit in a practicum context needs to be investigated. Adopting this approach to helping preservice teachers build their PCK could radically affect the way future science teachers are educated in methods courses, positioning teacher educators and preservice teachers as co-creators of knowledge. I believe these benefits could extend to both preservice and inservice professional development contexts.

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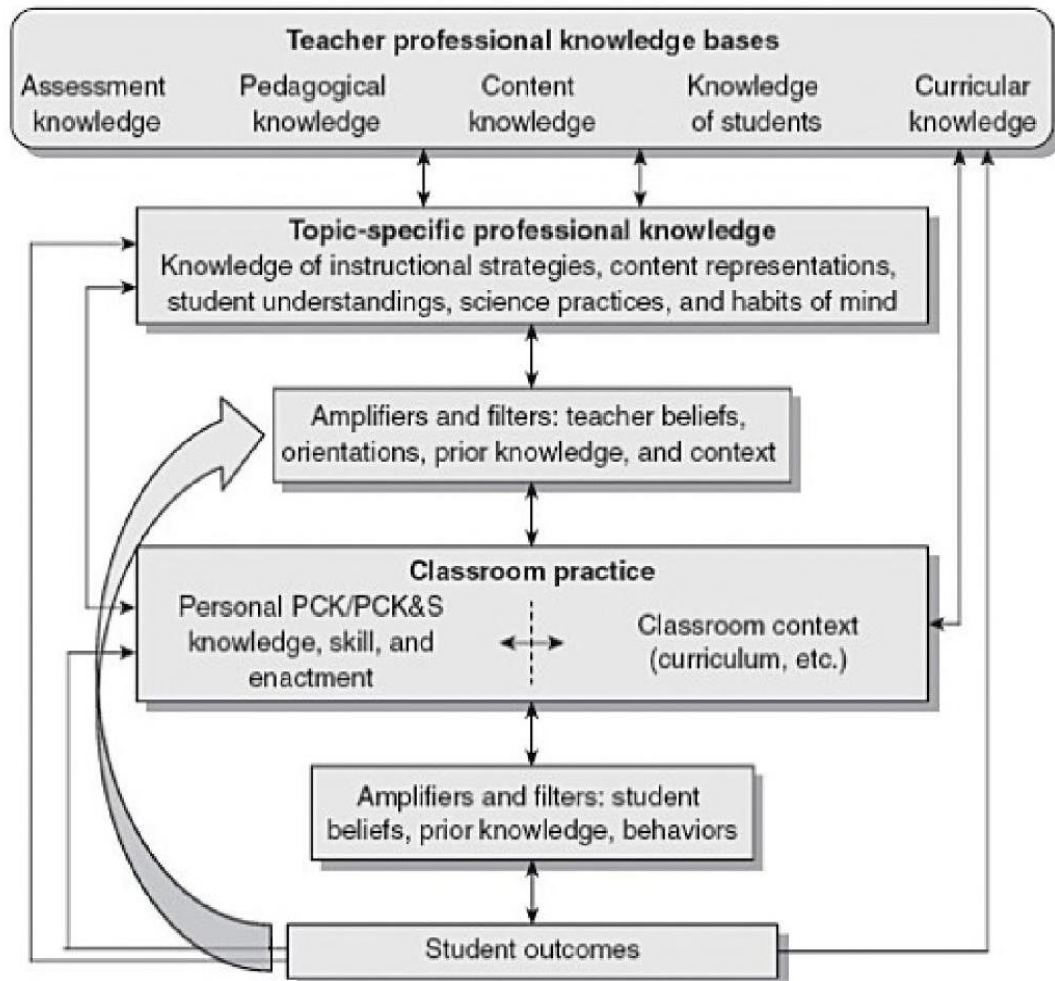
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## Appendix A

### Model of teacher professional knowledge and skill

(Gess-Newsome, 2015, p. 31)



Appendix B

Data Collection and Analysis Matrix

Research Questions	Constructs to Study	Data Sources	Analysis Procedures (by source & according to RQ constructs)
1. How do the abilities to professionally notice students scientific thinking develop as the preservice elementary teachers in this study participate in a four-week, moderator-led, professional learning community (PLC) featuring video-based reflections on practice, and to what aspects of the three scaffolds do participants attribute this development?	noticing	Individual written reflections lessons 1-4	Reflections will be inductively coded. Themes from inductive coding will be applied to van Es “Framework for Learning to Notice” to gauge the preservice teachers progression in learning to notice.
	noticing	Exit slips 1&4.	Exit slips analyzed using an open coding format
	noticing	post follow up interviews with selected participants	Interviews transcribed and analyzed using an open coding format
	noticing	Final survey	Final survey analyzed using an open coding format
	noticing	Researcher journal	Open coding allowing themes to emerge. I will also use to bracket my preconceptions

Research Questions	Constructs to Study	Data Sources	Analysis Procedures (by source & according to RQ constructs)
2 .How do the participants use what they have learned about student thinking to modify their instruction, and to what aspects of the three scaffolds do they attribute this change?	Responsive curriculum Noticing Student knowledge	Video whole group sharing PLC 3	For both teaching group and whole group PLC, I will create time-stamped video logs to pull out this aspect of the conversations. Logs will be inductively coded
	Responsive curriculum Noticing Student knowledge	Video teaching group PLC to modify next lesson 1-4	Will create time-stamped video logs. Logs will be inductively coded.
	Noticing Reflective Practice Orientations	Methods course post demographic surveys	Open coding format
	Noticing Reflective Practice Orientations	Methods course post lesson design task	Open coding format
	Noticing Reflective Practice Orientations	Follow up interviews	For follow up interviews I will be working from transcribed documents
Responsive curriculum Noticing Orientations	Exit slip 1	I will use open coding to determine themes	

Research Questions	Constructs to Study	Data Sources	Analysis Procedures (by source & according to RQ constructs)
3 .In what ways does the combination of these three scaffolds set within the context of a methods course affect these preservice teachers' development of their personal PCK and topic specific professional knowledge?	Reflective scaffolds PCK beliefs	Methods course post demographic surveys	Open coding format For follow up interviews I will be working from transcribed documents
	Reflective scaffolds PCK beliefs	Methods course post lesson design task	Open coding format For follow up interviews I will be working from transcribed documents
	Reflective scaffolds PCK beliefs	post follow up interviews	Will create time-stamped video logs to pull out that aspect of the conversations. Logs will be inductively coded
	Reflective scaffolds PCK	Video teaching group PLC 3 lesson modification portion	Will create time-stamped video logs to pull out that aspect of the conversations. Logs will be inductively coded
	Reflective scaffolds PCK beliefs	Researcher/content specific moderator journal	I will use as use the entries to bracket my preconceptions

## Appendix C

### Science Methods Course Demographics Survey (pre)

1. What year are you in? (e.g., junior or senior)
2. Since high school, list the science content courses you have completed and may be currently taking?
3. If you had to describe to someone what "Science" is, what would you say?
4. What is your favorite memory from learning science? What about that experience do you think made it your favorite memory?
5. What is your least favorite memory from learning science? What about that experience do you think made it your least favorite memory?
6. What do you think learning about science offers children? And what role should it have in an elementary curriculum?
7. How do you think science should be taught to children in grades K-6?
8. What resources will you consult when planning science lessons? *Please explain why you selected each of these.*
9. What methods will you employ to assess students' understanding of science concepts? What purpose will this information on student thinking serve you?
10. When reflecting on your teaching of science - whether it be to revise a lesson you just taught or to plan for the next lesson - What do you think you need to consider to help you with this revision process? Please explain why you think you should consider each item your list.

### Science Methods Course Demographics Survey (post)

*Directions: After answering each question, please be sure to discuss what aspects of the course and or related field experience you feel attributed to your current answer.*

1. If you had to describe to someone what "Science" is, what would you say?
2. What is your favorite memory from learning science? What about that experience do you think made it your favorite memory?
3. What is your least favorite memory from learning science? What about that experience do you think made it your least favorite memory?
4. What do you think learning about science offers children? And what role should it have in an elementary curriculum?
5. How do you think science should be taught to children in grades K-6?

6. What resources will you consult when planning science lessons? *Please explain why you selected each of these.*

7. What methods will you employ to assess students' understanding of science concepts? What purpose will this information on student thinking serve you?

8. When reflecting on your teaching of science - whether it be to revise a lesson you just taught or to plan for the next lesson - What do you think you need to consider to help you with this revision process? Please explain why you think you should consider each item your list.

## Appendix D

### Lesson Design Task Survey (pre)

Directions: We will use this information to inform us of how you will approach planning science lessons. We will ask you to complete a similar task at the end of the semester so we can see how your ideas for planning science lessons have changed. You will NOT be graded on this pre-assessment. It is being used for formative assessment purposes only.

---

#### **Scenario**

You are a third grade teacher and you have to teach your students about the properties of light. How would you design an introductory (1st lesson) on this topic? Respond to each of the questions below to demonstrate how you would plan a lesson to teach this topic.

1. What resources would you seek out to help you know what you need to teach about this topic?
2. What will be your learning objective for this first lesson?
3. Explain why you decided to start with this idea about light for the first lesson of your unit.
4. What ideas about light do you think your students may already have?
5. How will you introduce the lesson to the students?
6. What will you have students do to learn about the idea you have listed in your learning objective?
7. While your students are working with the task you have planned, what will you be doing?
8. How will you determine if your students - all students - met your learning objective?
  - What information will you gather from them? *If you are having them complete some sort of written task please create and include a copy of what this would be (e.g., a worksheet of some sort).*
  - What will you be looking for in this information to inform you that they have learned the objective for the lesson?
9. How will you decide what to do next?
10. Where did you get the idea for this first lesson? (e.g., if from a book please put the title, if a website please put the URL).

## Lesson Design Task Survey (post)

We will use this information to inform us of how your ideas for planning a lesson have changed over the course of the semester. We will compare what you provided in your pre lesson planning task to this post lesson planning task of the same lesson. You will NOT be graded on this post-assessment. It is being used for formative assessment purposes only.

### **Scenario**

You are a third grade teacher and you have to teach your students about the properties of light. How would you design an introductory (1st lesson) on this topic? Respond to each of the questions below to demonstrate how you would plan a lesson to teach this topic.

***ADDITIONAL NOTE: For each question please provide a short description about what readings, assignments, discussions (etc.) you experienced in your science methods class this semester that contributed to your answering of the question. In other words, what experiences INFORMED your decision about how to respond to each question. See question 1 (a) as an example of what we are asking you to write about.***

1. What resources would you seek out to help you know what you need to teach about this topic?
2. What will be your learning objective for this first lesson?
3. Explain why you decided to start with this idea about light for the first lesson of your unit.
4. What ideas about light do you think your students may already have?
5. How will you introduce the lesson to the students?
6. What will you have students do to learn about the idea you have listed in your learning objective?
7. While your students are working with the task you have planned, what will you be doing?
8. How will you determine if your students - all students - met your learning objective?
  - What information will you gather from them? *If you are having them complete some sort of written task please create and include a copy of what this would be (e.g., a worksheet of some sort).*
  - What will you be looking for in this information to inform you that they have learned the objective for the lesson?
9. How will you decide what to do next?
10. Where did you get the idea for this first lesson? (e.g., if from a book please put the title, if a website please put the URL).



## Appendix E

### Sample Lesson Design Task Follow Up Interview Protocol

\*\*Same protocol will be used for both pre and post with the addition of some questions focused on how their answers changed for the post and what they attribute that change to

(Adapted from Frierichsen et al., 2009)

**Say to participant:** Thank you again for participating today. During this interview, I will be asking you questions about your plan and what you thought about when you wrote the plan .I am interested in how you are thinking at this point; there are no right or wrong answers to the questions here.

Start the audio-recorder.

#### **Talking Through the Plan**

**Say to the participant:** The first part of the interview is about your responses to the 10 questions about planning a lesson on light. I want to make sure that I understand your plan and what you intended.

**Begin with this question:** What did you think about as you were designing this lesson?

Then ask the participant to walk you through their plan by asking:

Walk me through your plan. How did you start the first day? Continue to ask clarifying questions; your task is to be able to really understand what the participant intended for each part of the plan.

Possible clarifying prompts:

- What did you mean when you wrote?
- Could you clarify what the students are doing during this part?
- Could you clarify what you are doing during this part?
- Could you tell me why you decided to do that?

#### **Probing Participant's Knowledge**

**Subject Matter Knowledge (SMK).** *Say to the participant:* One part of what a teacher needs to know is something that we call subject matter knowledge. In your case, we mean your own understandings of the science that you will be teaching. These next questions are designed to probe what you know about light. Again, there is no right or wrong answers. We are interested in what you know and how you think about light at this point.

1. What are your previous experiences with the topic of light?
  - How well do you think you know (this topic)?
  - Where did you learn about this topic?
  - Have you taught (this topic) previously?
2. What do you think is important for 3<sup>rd</sup> grade students to know about light?
  - Why do you think that is important?
  - Tell me about where you learned these things?
  - What else do you know about light that students might not need to know?
3. Talk to me about how your plan addresses these things (Probe for specifics based on the plan).
4. In what ways does the topic of light fit into the “big science picture” of what students learn about science in elementary school?

**Knowledge of Students.** *Say to the participant:* Another part of what a teacher knows has to do with how students think about science. The next questions are designed to probe what you know about how students might think about light.

1. What do you think students will already know about this topic?
  - Why do you think that they may know that?
  - Where do you think they may have learned this?
2. Do you expect students to have difficulty with anything that you have planned?
  - Why do you think they will have difficulty with that?

**Knowledge of Instructional Strategies.** *Say to the participant:* We want to know more about how you organized the instruction. The next questions will help us better understand your decisions about what and how to teach about light.

1. From your plan, it appears that you chose to organize the class as (i.e., lecture, experiment, investigation). Talk to me about making that decision.

- Where did you learn about how to teach this way?
- Did you consider organizing the classes in a different way? Why/why not?

IF NO TO THE LAST QUESTION: Teachers often develop a range of ways to think about organizing their class; why do you think you chose this way to think about it?

2. I noticed that you used a picture (graph, equation, analogy. . .) in your plan. Tell me why you used that at that point in your plan.

- How do you think this (picture, graph, equation, analogy) helps students learn about light?
- Did you consider representing that idea another way?

**Knowledge of Curriculum.** *Say to the participant:* These next questions are designed for us to know something about where your ideas for this plan came from.

1. Where did you get your ideas for this lesson plan?

- If you had access to other resources, what would you like them to be?

2. Tell me about the materials (handouts, transparencies) you prepared.

- Where did you get the ideas for these materials?
- How do you think these materials will help or hinder achieving the purpose your plan?

**Knowledge of Assessment.** *Say to the participant:* The last area I want to ask you about is how you will know what students learn from this lesson.

1. During this lesson, describe how you will know if students are “getting it.”

2. In my experience as a teacher, there are inevitably some students who are still confused at the end of each class. How will you know if your students are confused at the end of each day in your class?

- Are there other ways that you might know what your students learn during this this lesson?
  - Is there anything else about your lesson that you want us to know?     ^^
-

## Appendix F

### Sample Weekly Schedule for Implementing Scaffolds

#### Cycle of Events Following Each Week of Teaching a Science Lesson

Monday	Wednesday	Thursday*	Friday
Students will have until midnight Monday to complete and submit individual written reflections that include timestamps of the video clips they will share in the PLC on Wednesday.	PLC meeting will occur during the scheduled science methods class (Wednesdays from 11:00-12:15). Video equipment will also be passed out at the end of the each period for the preservice teachers to record their teaching in the classroom the next day.	Students will be in the field teaching their lessons. One member of each group who is not the lead teacher for that week will be responsible for video recording the teaching session. I will pick up video equipment from them at the end of the day at the school site.	Video will be uploaded by Friday afternoon so preservice teachers can access it to complete their individual weekly reflections by Monday at midnight.

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\*The weekly cycle begins this day, as it is the teaching day in the field.

## Appendix G

### Individual Video Viewing and Written Reflection

*This document will be distributed to the students in a preliminary workshop and posted to Canvas for reference.*

\*\*\*\*\*

#### ***DIRECTIONS:***

Video will be uploaded by Friday afternoon. All members of each professional learning community (PLC) will watch and respond to the following prompts before midnight on Monday. Please submit your reflection to drop box on canvas.

To prepare your reflection paper, follow these steps:

1. Watch the entire lesson first to get a sense of what happened.
2. Go back and watch the lesson a second time, this time to complete the following task.
  - a. Select at least 3 examples where you noticed attention being given to student thinking during the lesson.
    - i. Also consider places where attention to student thinking was missed or could have been explored more fully?
  - b. Be sure to include the timestamps (beginning and end) for each clip.
3. From the three clips you selected, choose 1 clip to discuss with your PLC in class on Wednesday. Write a response to each of the following questions regarding this clip. Your responses to these questions is what you will share with your PLC
  - a. How does this instance relate to teaching or learning of the lesson objectives?
  - b. Is there anything about the context that you think affected the situation?
  - c. How would you change the lesson to more fully address students' needs?
4. Your weekly reflection paper needs to include:
  - o The three examples you selected (bullet 2) and the timestamps for each.
  - o Your responses to the three questions outlined in bullet 3 with respect to your "chosen" clip to share in your PLC.

## Appendix H

### Example of PLC Agenda (Teaching Group and Whole Group) – held each Wednesday ALL PLC GROUPINGS WILL BE VIDEO RECORDED

#### Teaching Group PLCs- video reflection

- 10 min sharing how they prepared their written reflection to share with PLC members – why they chose their specific clip.
- 20 min sharing of selected video clips with teaching groups
  - During this time I will be going around to different PLCs asking questions 1-4 listed in Appendix H.

*Directions for Teaching Group PLC discussion:* The PLC begins with each member sharing why they selected their clip to share in the PLC (e.g., what they think it illustrates about students' science thinking (the first 10 min segment). Next, each member takes turns sharing their chosen clip and after viewing each clip the group stops to discuss aspects of attending to student thinking that each of them noticed. This may be the same or different from what the PLC member who is sharing the clip stated as what they noticed. The following questions will be provided initially to help PLC members with noticing while watching the short video clips.

- What scientific concept is being addressed in the lesson?
- In what ways did you see the teacher attending to students' thinking about this concept?
- What is the student exhibiting they know about this concept?
- Do you notice any misconceptions in the students' thinking about this concept?

#### Whole Class PLC- video reflection

- 20 min whole group reflection of 1 group's video (each week 1 group's video will be selected to reflect on as a whole group in order to develop a common vocabulary for discussing noticing and to allow the moderator to model and scaffold the process) /initiate process by discussing core protocol.

#### Teaching Group PLCs – lesson modification

- 20 min for small group PLCs to reconvene and discuss modifications they want to make to their next lesson based on the initial small group video-reflection segment and whole class PLC segment.
  - During this time I will be going around to different PLCs asking questions 5-8 listed in Appendix H.

#### Individually- Written Exit Slip

- 5 min for each person in the class to complete a short written reflection (exit slip) on their PLC experience for the day.

## Appendix I

### Sample Questions asked by moderator during Video Reflection and Lesson Modification (Adapted from Nilsson & Loughran, 2012)

#### NOTE:

The following are a list of questions that I (the content specific moderator) will ask to small group PLCs as I circulate the room during the small group PLC video sharing and lesson revision time. Bolded questions will be key questions asked to all groups each week. Due to time constraints not all of the remaining questions will be asked each week.

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#### 1<sup>st</sup> teaching group PLC session (video reflection) & Whole group PLC session (video reflection)

1. **What is the science idea you were trying to teach about in this lesson and what did you intend students to learn about his idea?**
2. Why is it important for students to know this?
3. What else do you know about this idea (that you do not intend students to know yet?)
4. What difficulties/limitations did you find were connected with teaching this idea?

#### 2<sup>nd</sup> teaching group PLC session (lesson modification)

5. What is your knowledge about students' thinking on this topic that is influencing your thinking about how to teach this science concept?
6. Are there other factors influencing your teaching of this idea? What are they?
7. **What teaching procedures/strategies are you modifying in your lesson?**
  - a. **What are your reasons for these modifications?**
  - b. **How will you ascertain if students' continue to have difficulties understanding or have confusion with this idea?**
8. **How do you think the activities/ materials you have chosen will support the students in meeting the learning objective(s) of the lesson?\***

*\*added to Nilsson & Loughran's original questions*

Appendix J

Sample Exit Slips Questions

(Modified from: Luft &Roehrig, 2007)

NOTE:

1-2 will be asked at the end of each PLC session for a total of four weeks.

\*\*\*\*\*

1. How will you maximize student learning in your classroom? (learning)
2. How would you describe your role as a teacher? (knowledge)
3. How will you know when students understand? (learning)
4. How will you decide what to teach and what not to teach? (knowledge)
5. How will you decide when to move on to a new topic in your classroom? (knowledge)
6. How do students learn science best? (learning)
7. How do you know when learning is occurring in the classroom? (learning)

## Appendix K

### New Protocol and Focusing Questions

**5 min** debrief

**25 min** Teaching groups reflecting on student thinking by watching video of last lesson taught and practicing noticing skills with their teaching group PLC. Share clips and discuss how S thinking could have been probed further.

**30 min** Decide what to do with what you learned

10 minutes: What was the main issue with student thinking in the lesson you just watched and how would you modify that lesson to address this?

10 minutes: Consider if next lesson has same problem. Is it really focusing on what you want it to? Is it designed to uncover student thinking?

10 minutes: Work on in enacting the modifications. (Is activity and wrap up - structured in a way that S are being asked to think, explain, interpret and analyze? Is worksheet-exactly targeting what we want to know about these kids thinking?)

**10 min** share with whole group issues and modifications from the last lesson and our modification of the next lesson

**5 min** exit slip

### What to do with what you've learned

#### Part A:

Thinking about the in depth look at student thinking in your last lesson

What was the main issue with student thinking/understanding about science concept?

How would you modify the lesson to address this issue if you taught it again?

#### Part B:

Now look at your next lesson with critical eyes – given what you found in the last lesson do you see the potential of this problem occurring in the next lesson

What do you want to emphasize? Do you want to reframe the questions to ensure this emphasis, if so how?

How does your lesson set up have students discuss and think about the concept in order to achieve that emphasis?

How does your worksheet specifically support this goal?

How did you modify the lesson today?



## Appendix L

### Last Meeting Agenda and Final Survey Questions

For the Lesson Study time in the field on Thursday. I'm planning on having an individual writing component)at the beginning to give me time to connect the video of the lesson they just recorded to a monitor so they can watch it and also to give me the feedback for some questions I have. (See following for a list of questions I am thinking of including.) Then having them select a section to watch from their video in order to reflect on student thinking, sharing places student thinking was uncovered or could have been uncovered more thoroughly. Then finally I will have them reflect orally as a group on the effectiveness of their learning progression.

#### Final Survey

1. Please describe your overall impressions of the intervention, include what you felt was useful and why and components you didn't feel were useful or necessary and why, and finally suggestions for improvement.
2. Please describe your understanding of professional noticing and how and how and why it is used.
3. What if anything that you learned from this intervention do you think you will utilize in your future teaching?
4. How does a learning cycle lesson affect student learning and why?
5. Since we didn't have a time to share out in yesterday's PLC, 1) please state the issue your group found with lesson 4 and how would modify the lesson if you were to teach it again and then state how you modified the last lesson (make sure to state your reasoning behind the change).